US010293522B2

(12) United States Patent
Li et al.

(10) Patent No.: US 10,293,522 B2
(45) Date of Patent: May 21, 2019

(54) **MULTI-PIECE MOLD AND METHOD OF MAKING SLURRY DISTRIBUTOR**

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(73) Assignee: **United States Gypsum Company**, Chicago, IL (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 600 days.

(21) Appl. No.: **13/659,600**

(22) Filed: **Oct. 24, 2012**

(65) **Prior Publication Data**

US 2013/0099418 A1 Apr. 25, 2013

Related U.S. Application Data

(60) Provisional application No. 61/550,827, filed on Oct. 24, 2011.

(51) **Int. Cl.**
B29C 41/14 (2006.01)
B29C 37/00 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***B29C 41/14*** (2013.01); ***B29C 33/485*** (2013.01); ***B29C 37/0014*** (2013.01);
(Continued)

(58) **Field of Classification Search**
None
See application file for complete search history.

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(57) **ABSTRACT**

A multi-piece mold for use in a method for making a slurry distributor includes a plurality of mold segments adapted to be removably secured together. The mold segments are configured such that, when the mold segments are assembled together, the assembled mold segments define a substantially continuous exterior surface adapted to be a negative image of an interior flow region of a slurry distributor molded thereupon. Each mold segment has a maximum cross-sectional area in a plane substantially transverse to a direction of movement of the mold segment along a removal path out of a respective opening of the molded slurry distributor. The maximum cross-sectional area of each mold segment is up to about 150% of the smallest area of the interior flow region of the molded slurry distributor through
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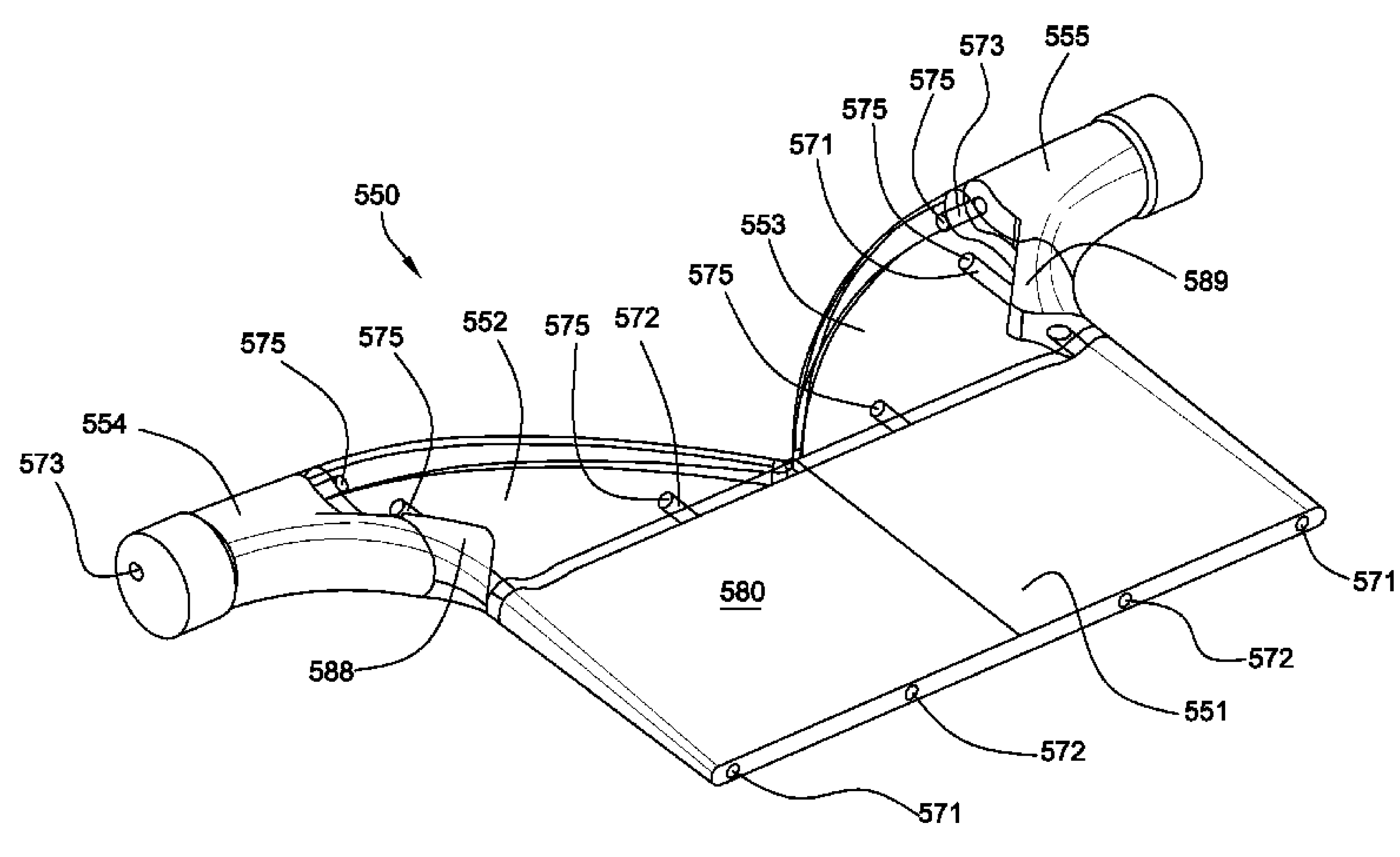

which the mold segment traverses when moving along the respective removal path.

9 Claims, 48 Drawing Sheets

(51) **Int. Cl.**

B29C 33/38	(2006.01)
B29C 33/48	(2006.01)
B29C 41/38	(2006.01)
B29C 41/42	(2006.01)
B29C 33/50	(2006.01)
B29C 33/44	(2006.01)
B29L 31/00	(2006.01)
B29C 33/00	(2006.01)
B28B 19/00	(2006.01)

(52) **U.S. Cl.**

CPC ***B29C 37/0017*** (2013.01); ***B29C 41/386*** (2013.01); ***B29C 41/42*** (2013.01); *B28B 19/0092* (2013.01); *B29C 33/0033* (2013.01); *B29C 33/44* (2013.01); *B29C 33/448* (2013.01); *B29C 33/48* (2013.01); *B29C 33/50* (2013.01); *B29C 33/505* (2013.01); *B29L 2031/757* (2013.01)

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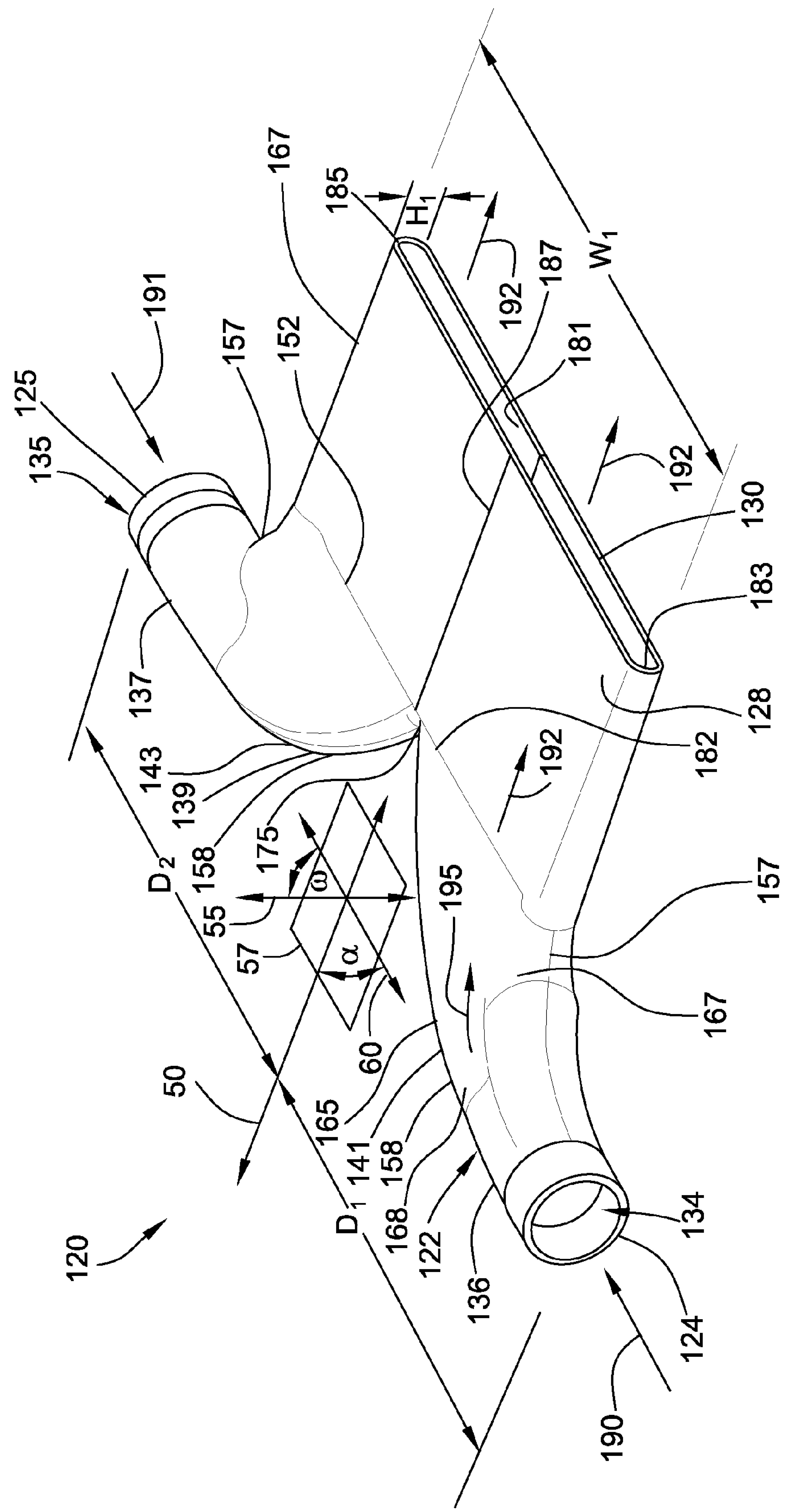
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FIG. 1

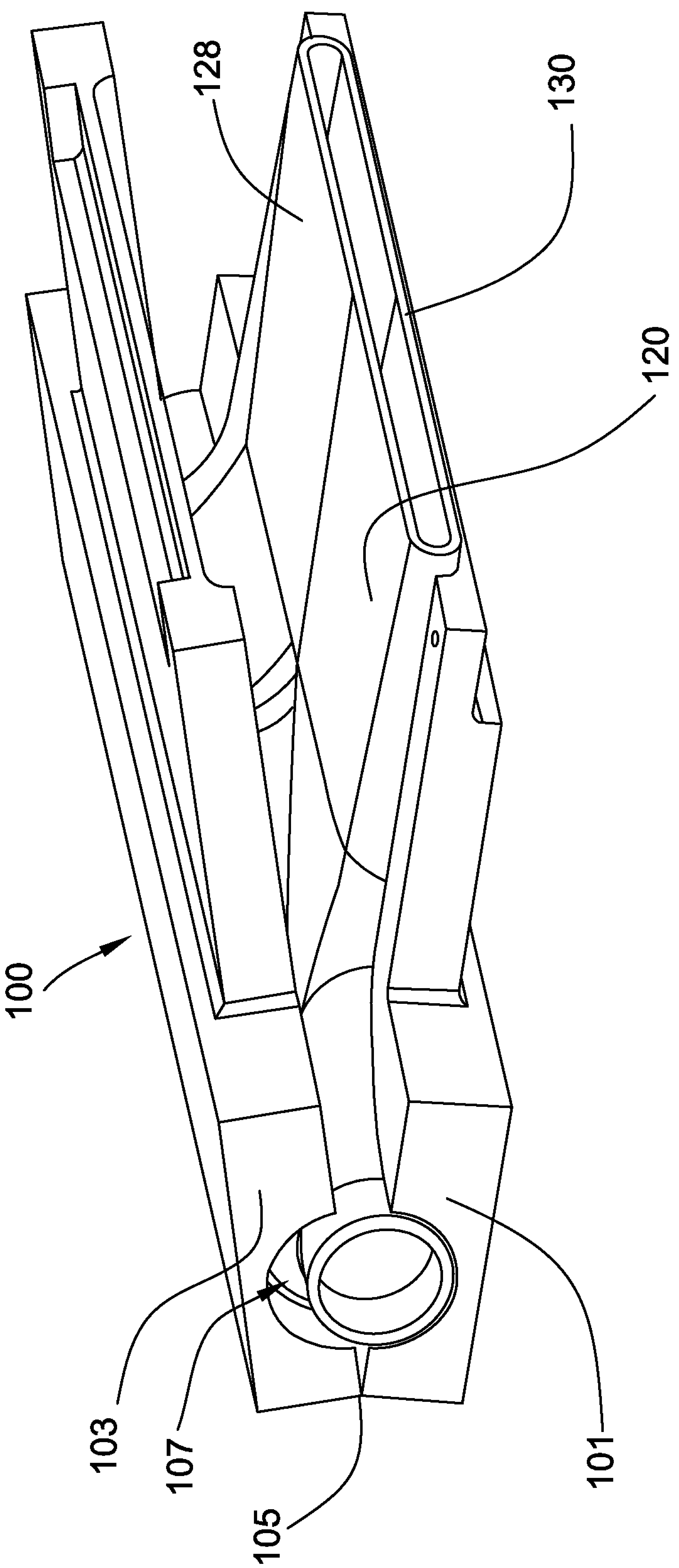

FIG. 2

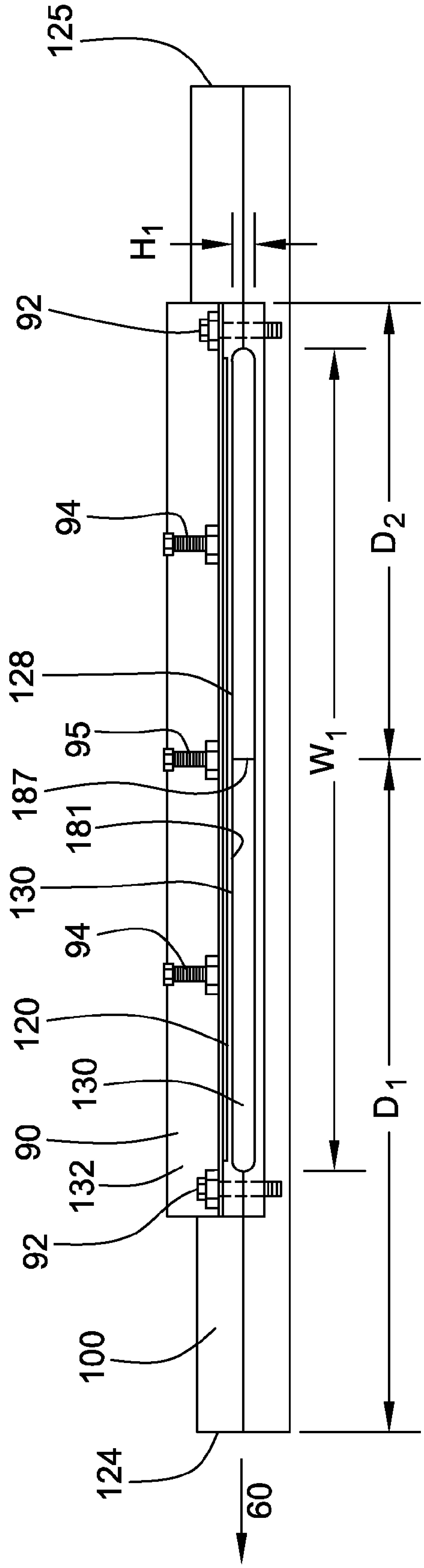
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FIG. 3

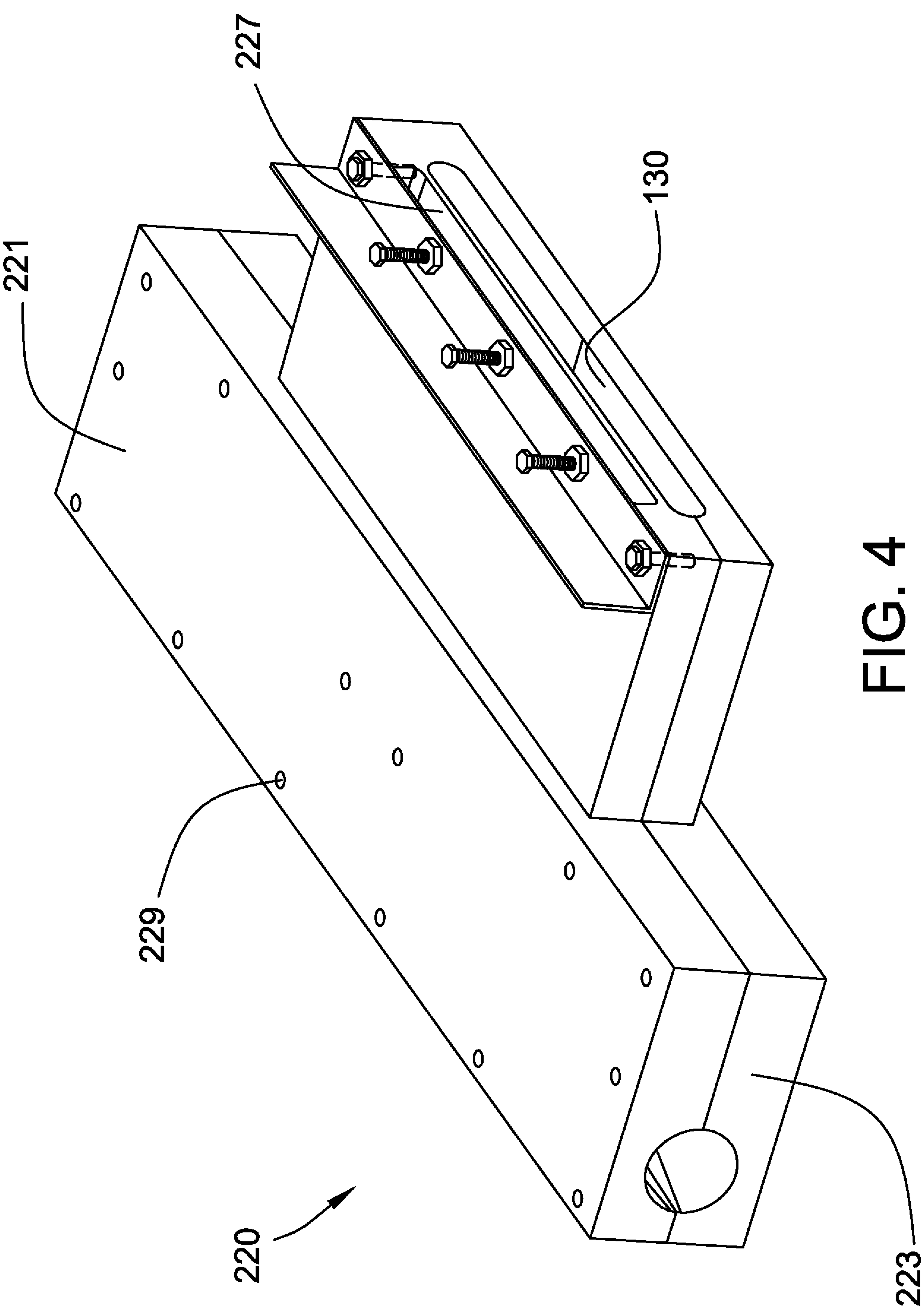

FIG. 4

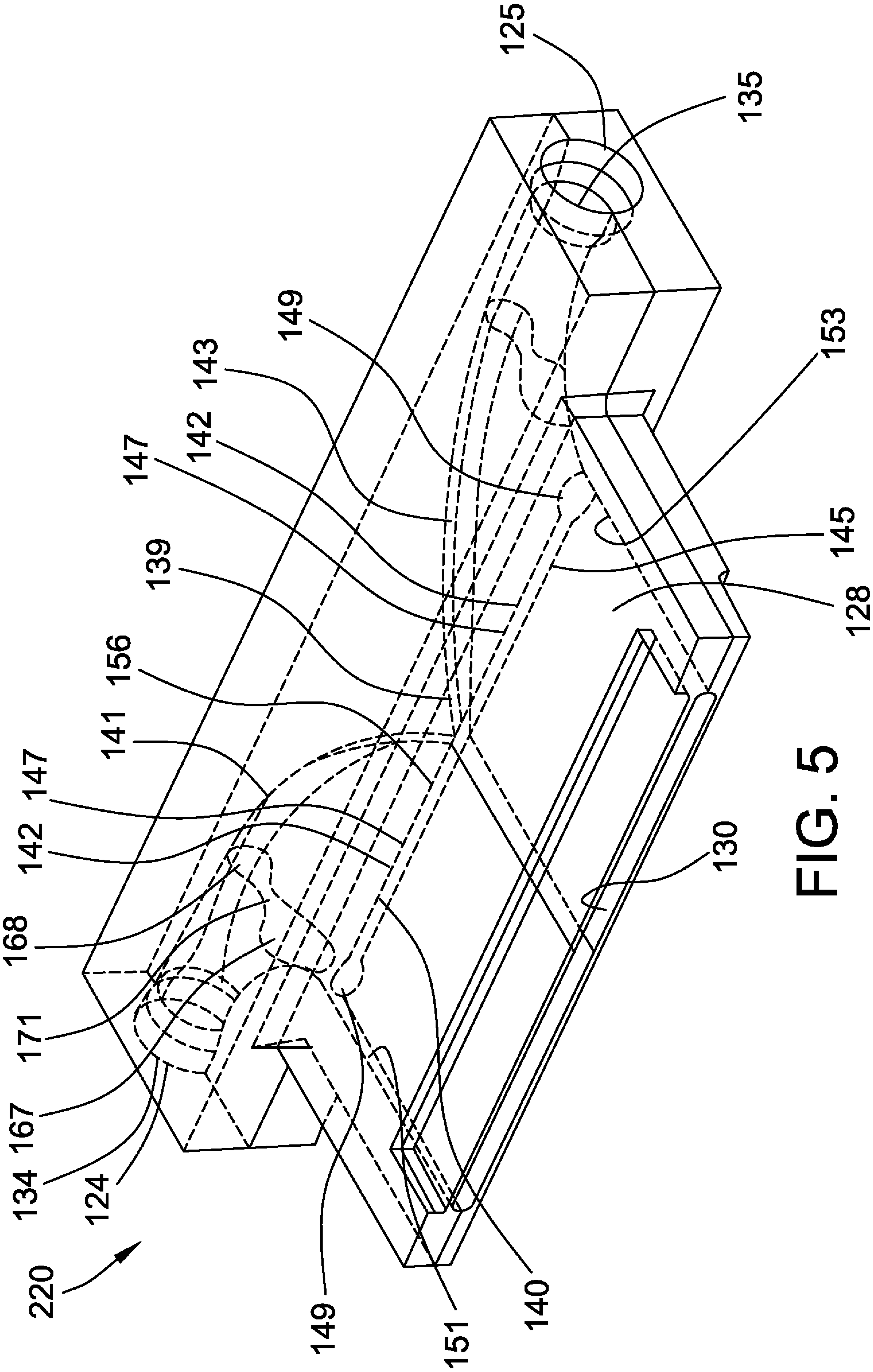
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FIG. 5

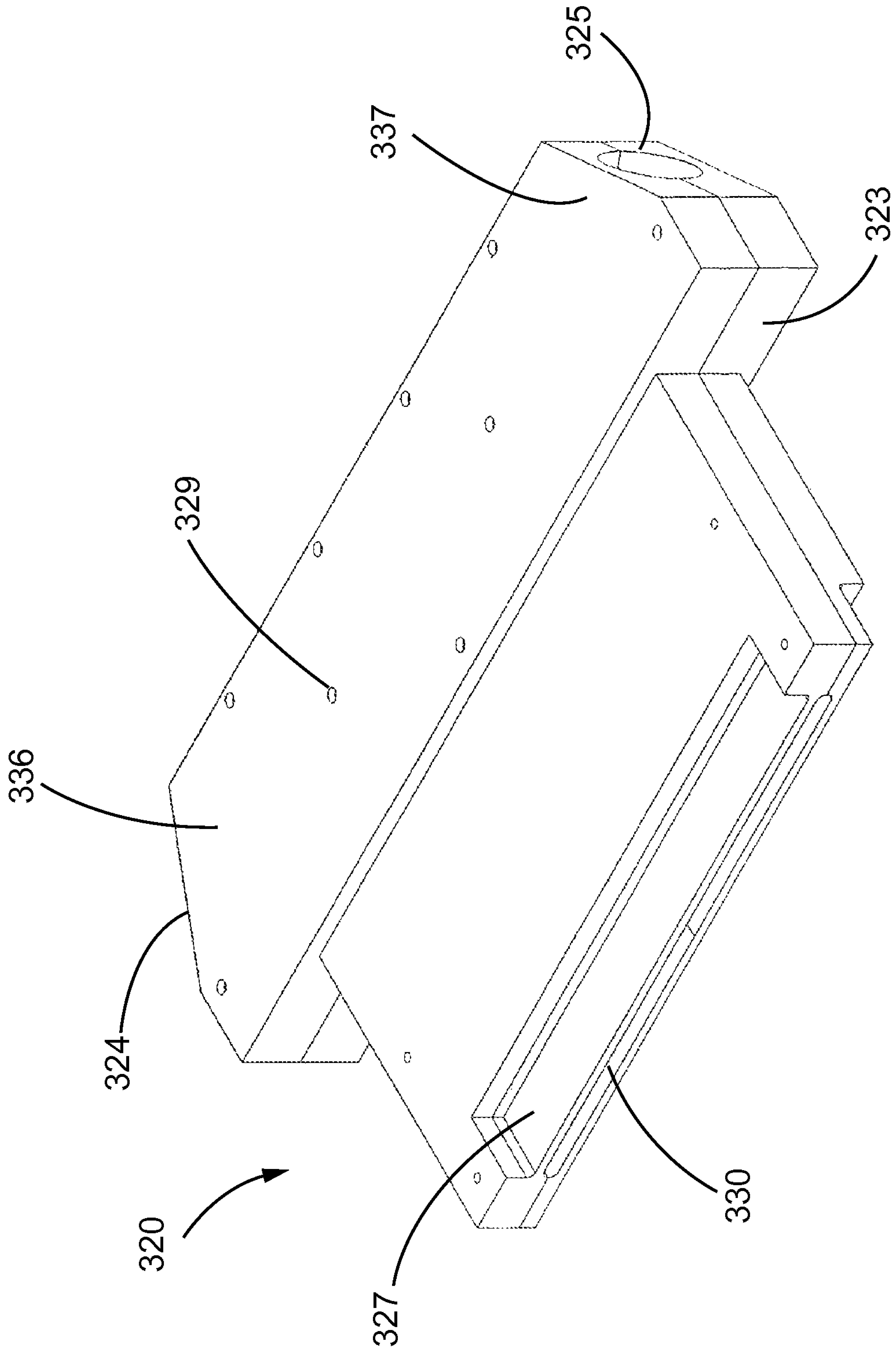

FIG. 6

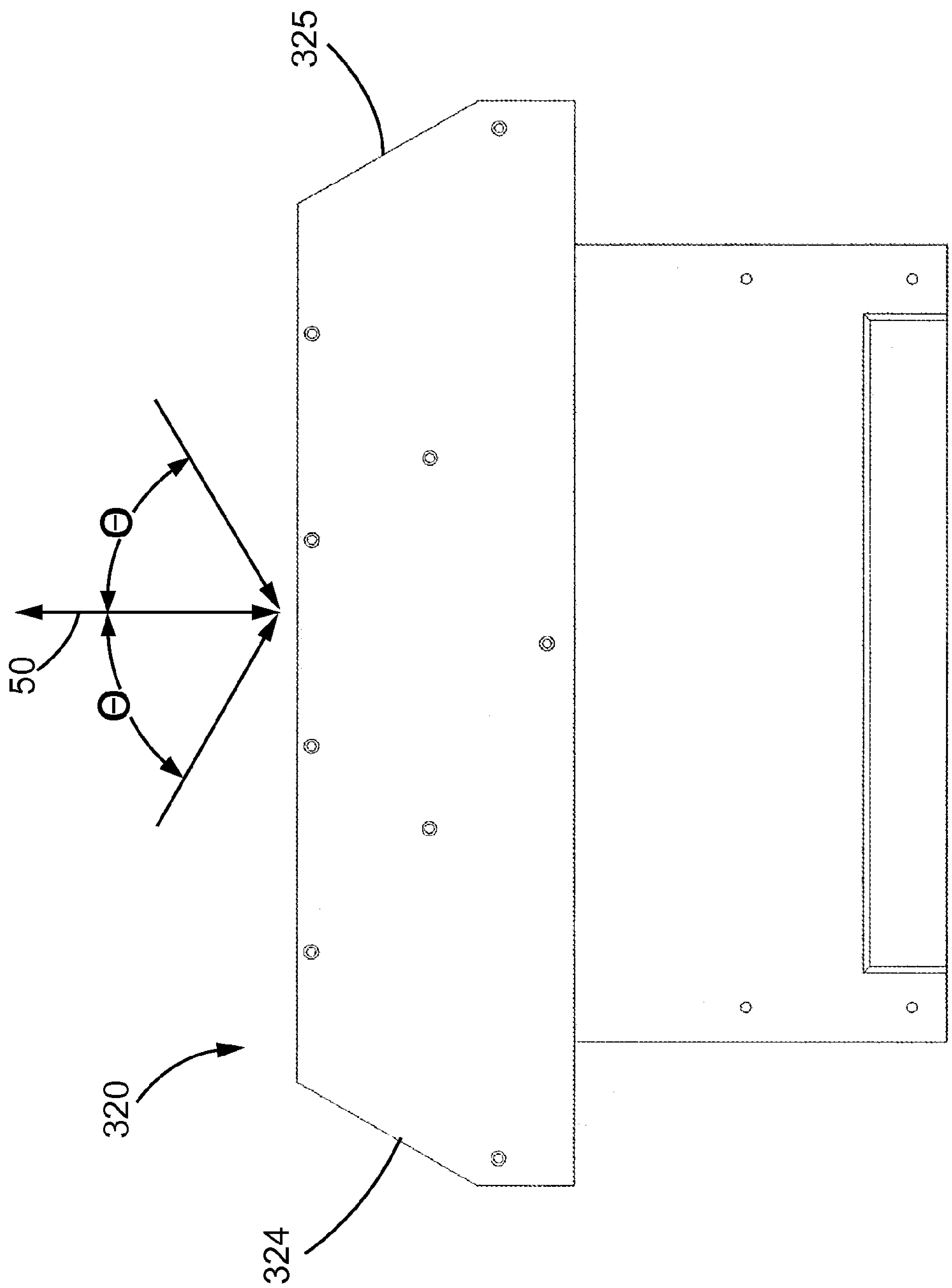

FIG. 7

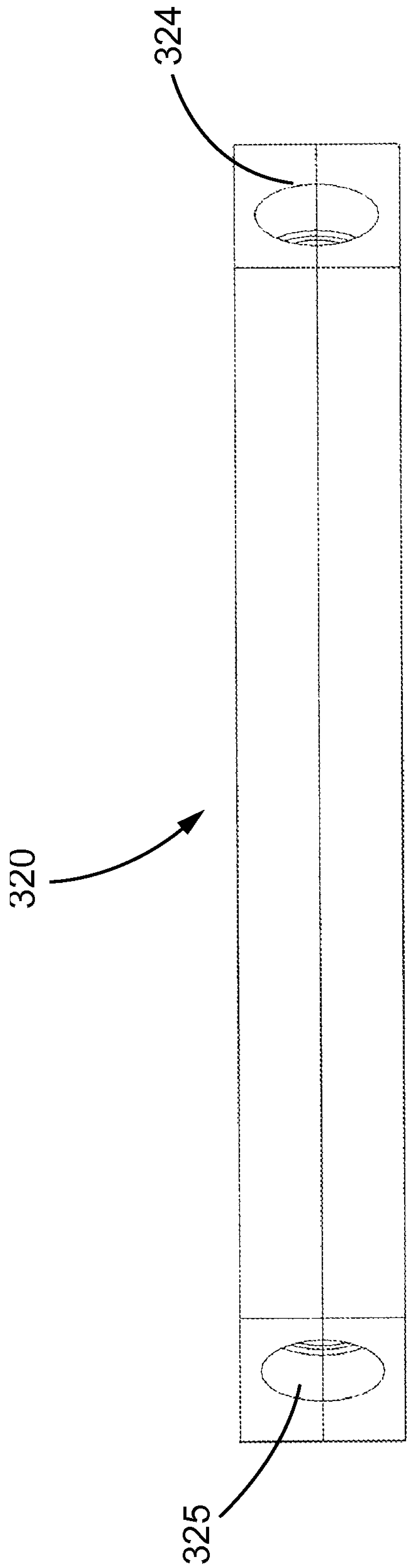

FIG. 8

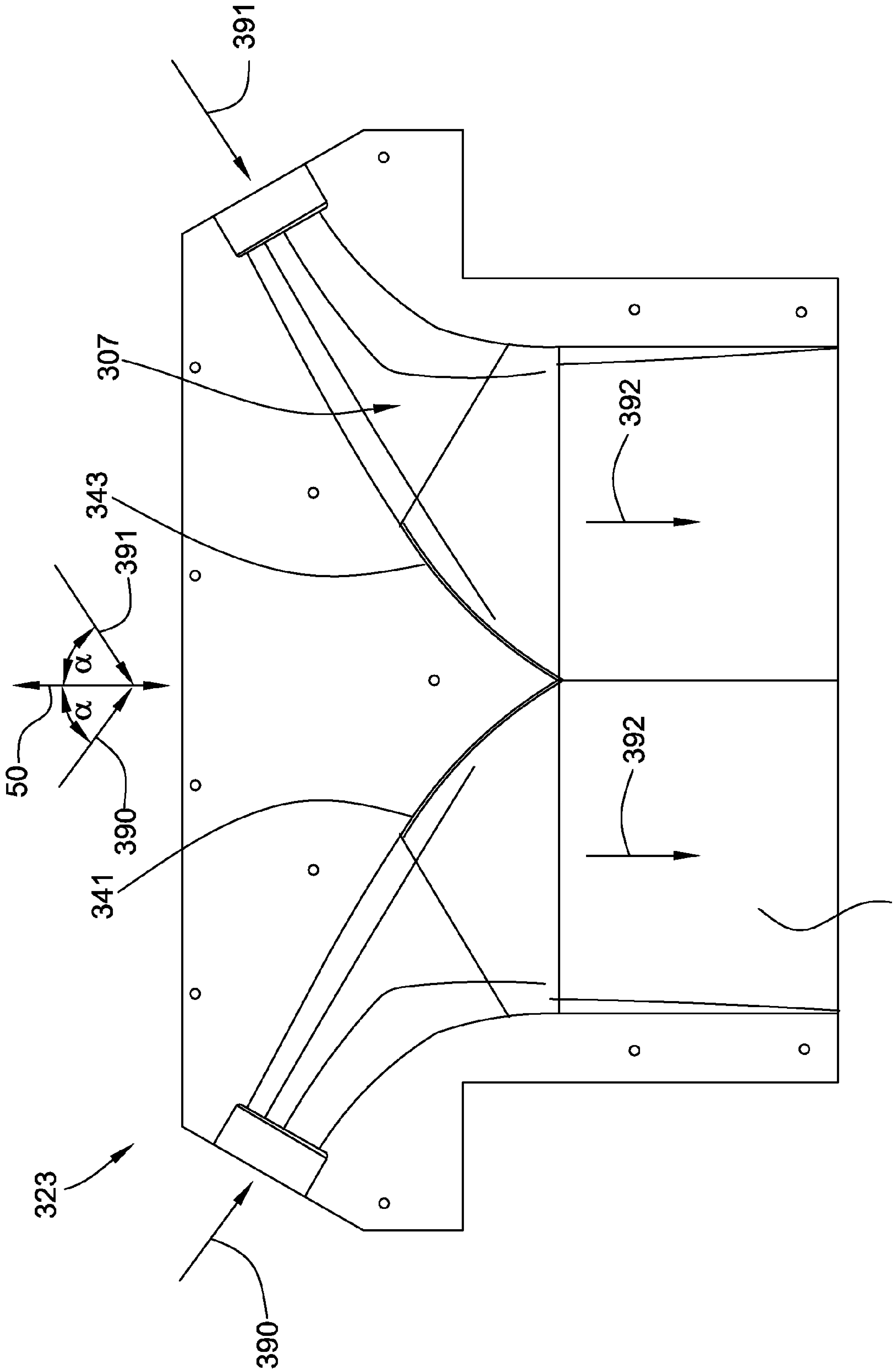

FIG. 9

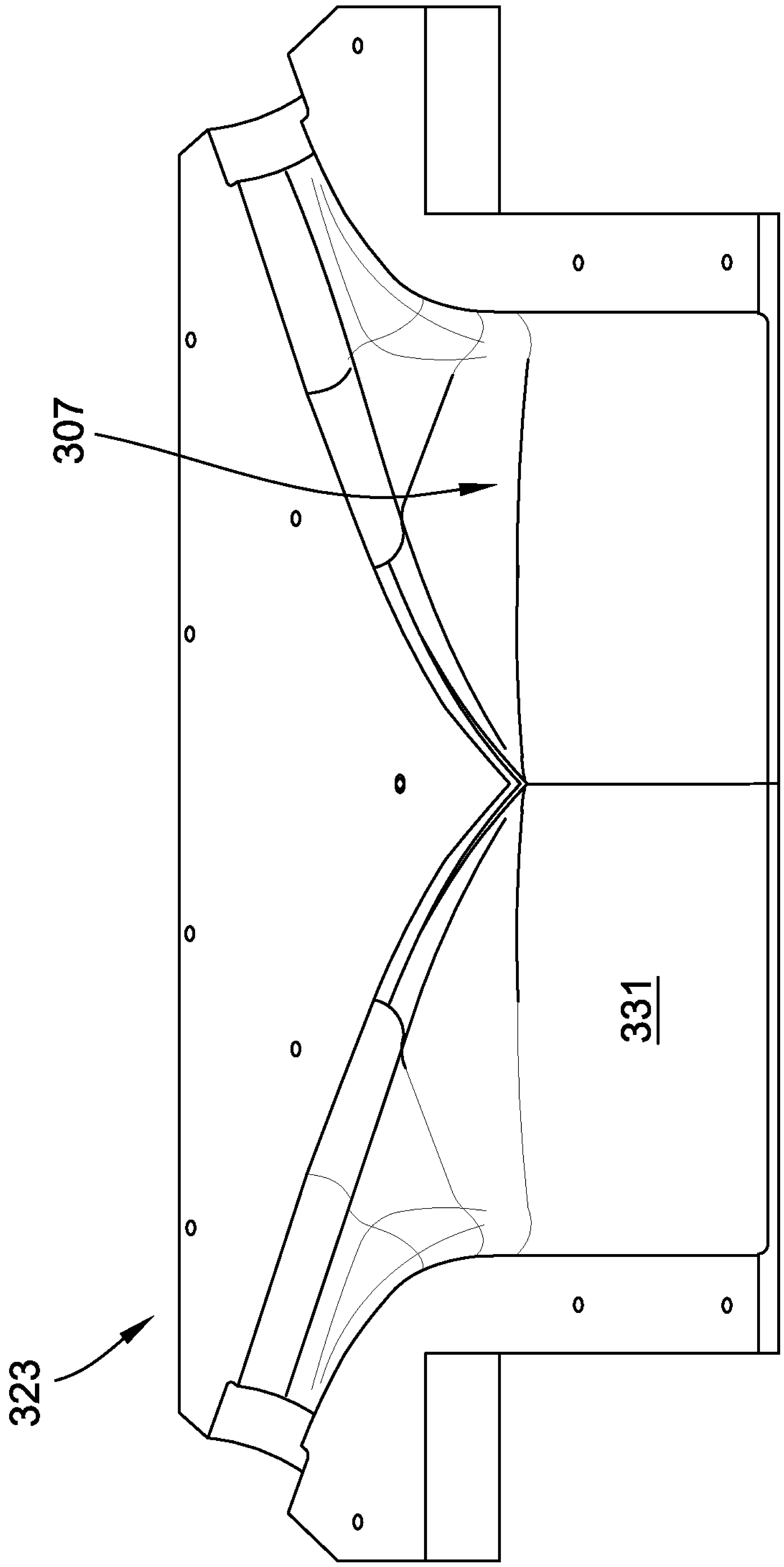

FIG. 10

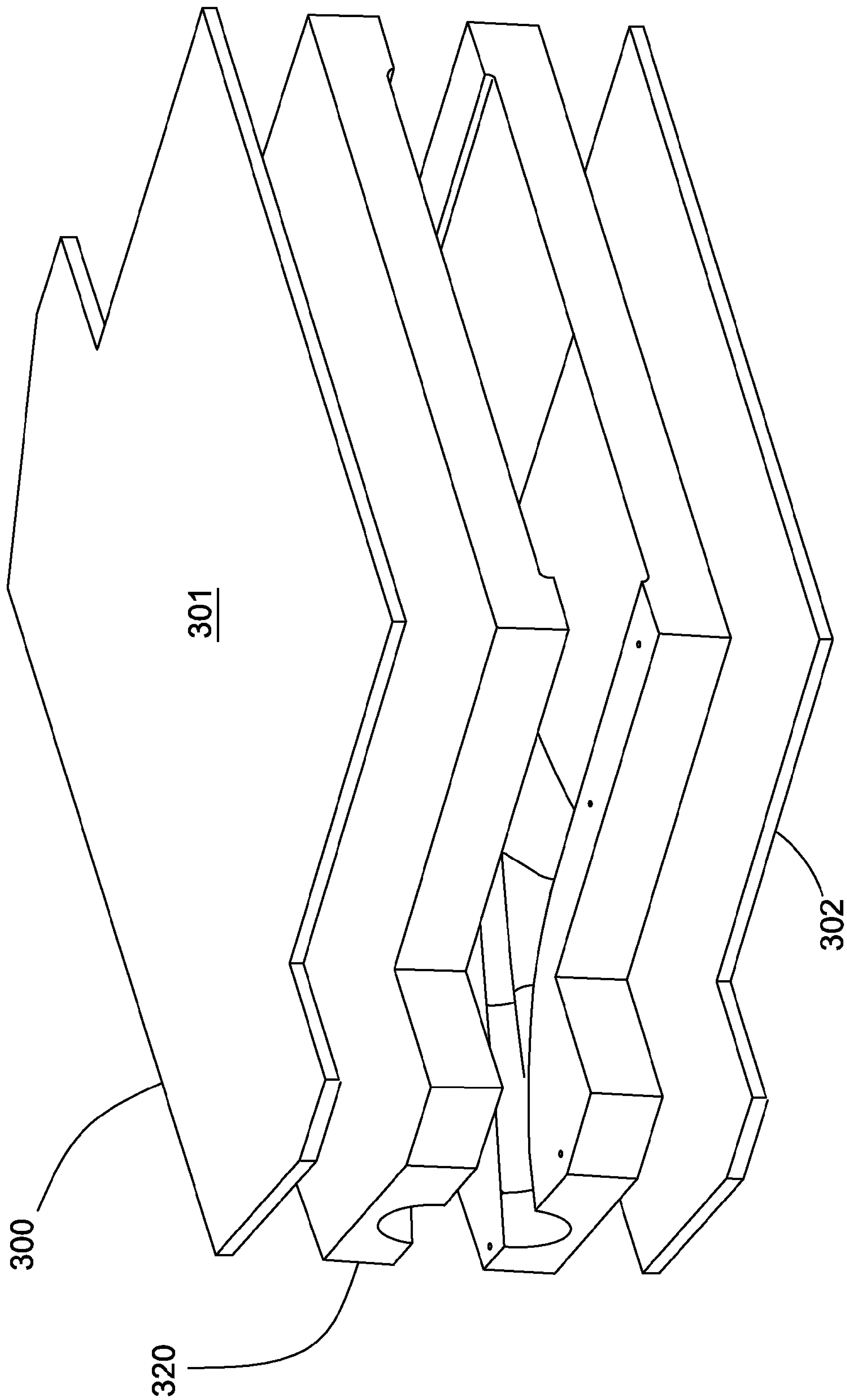

FIG. 11

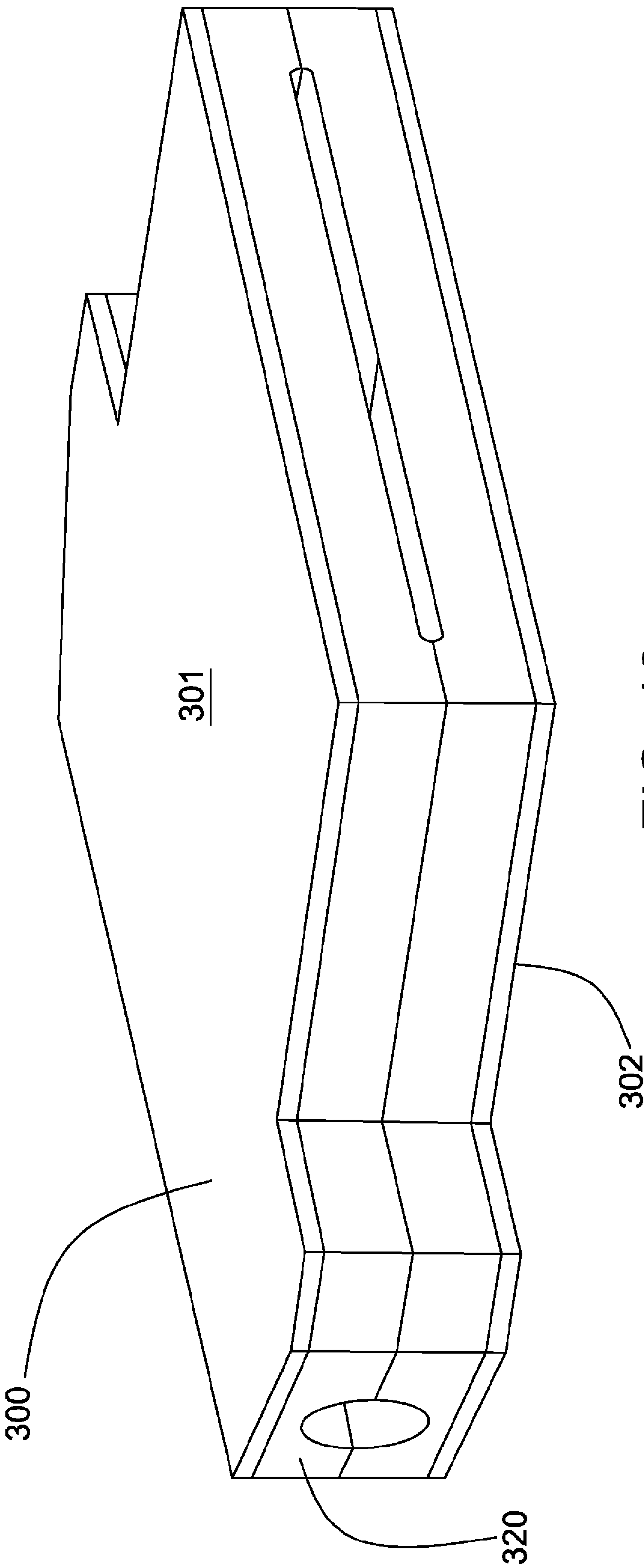

FIG. 12

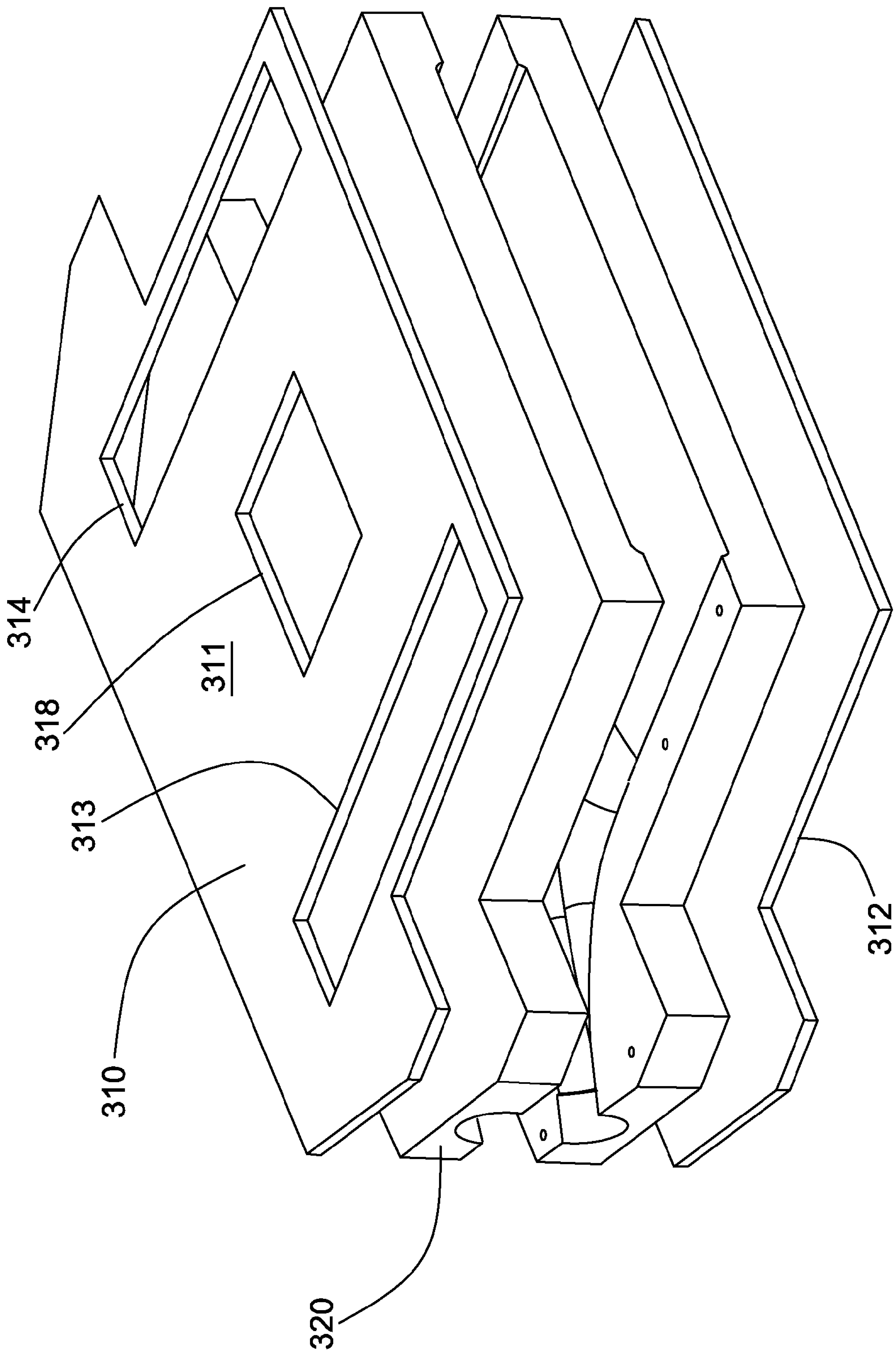

FIG. 13

FIG. 14

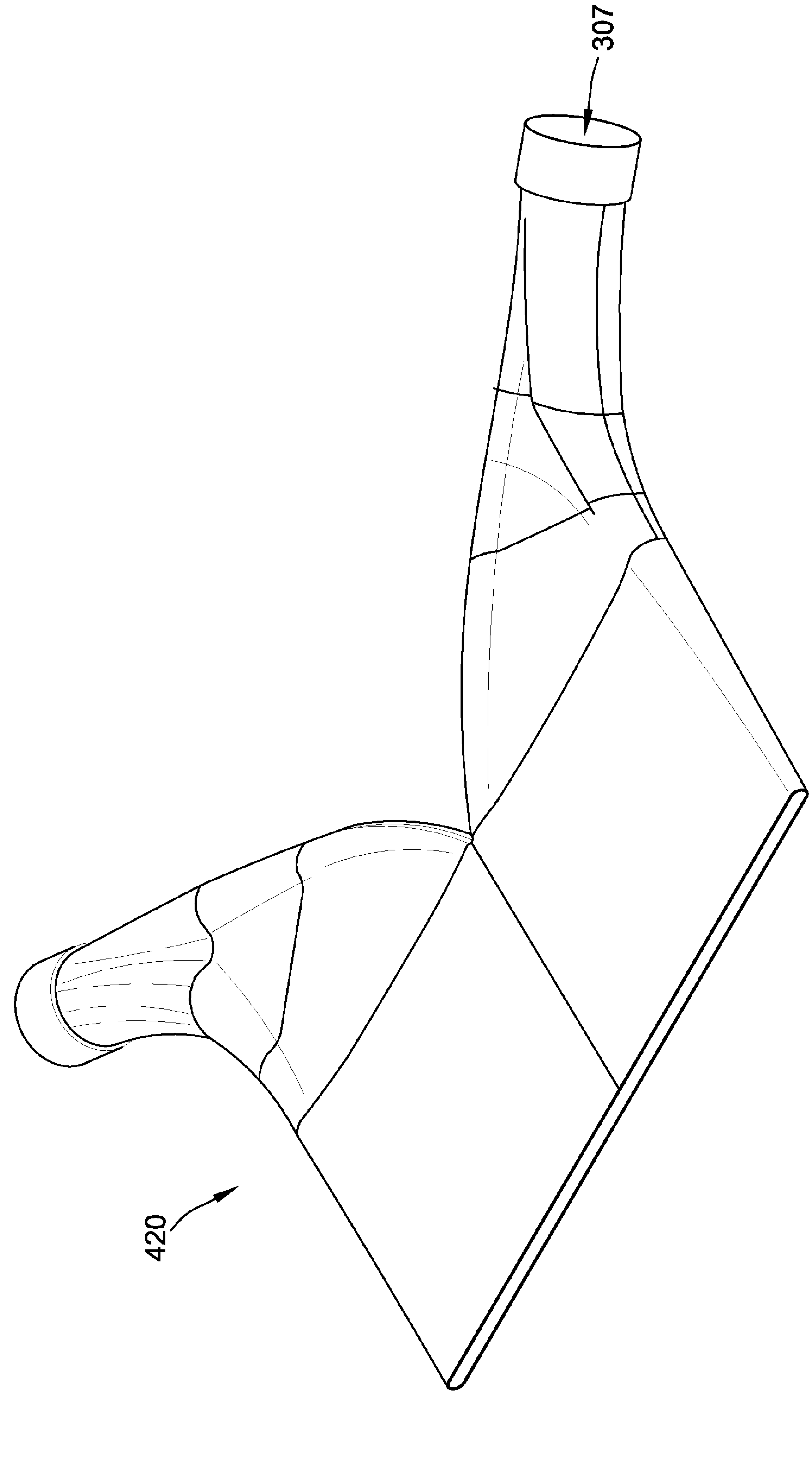

FIG. 15

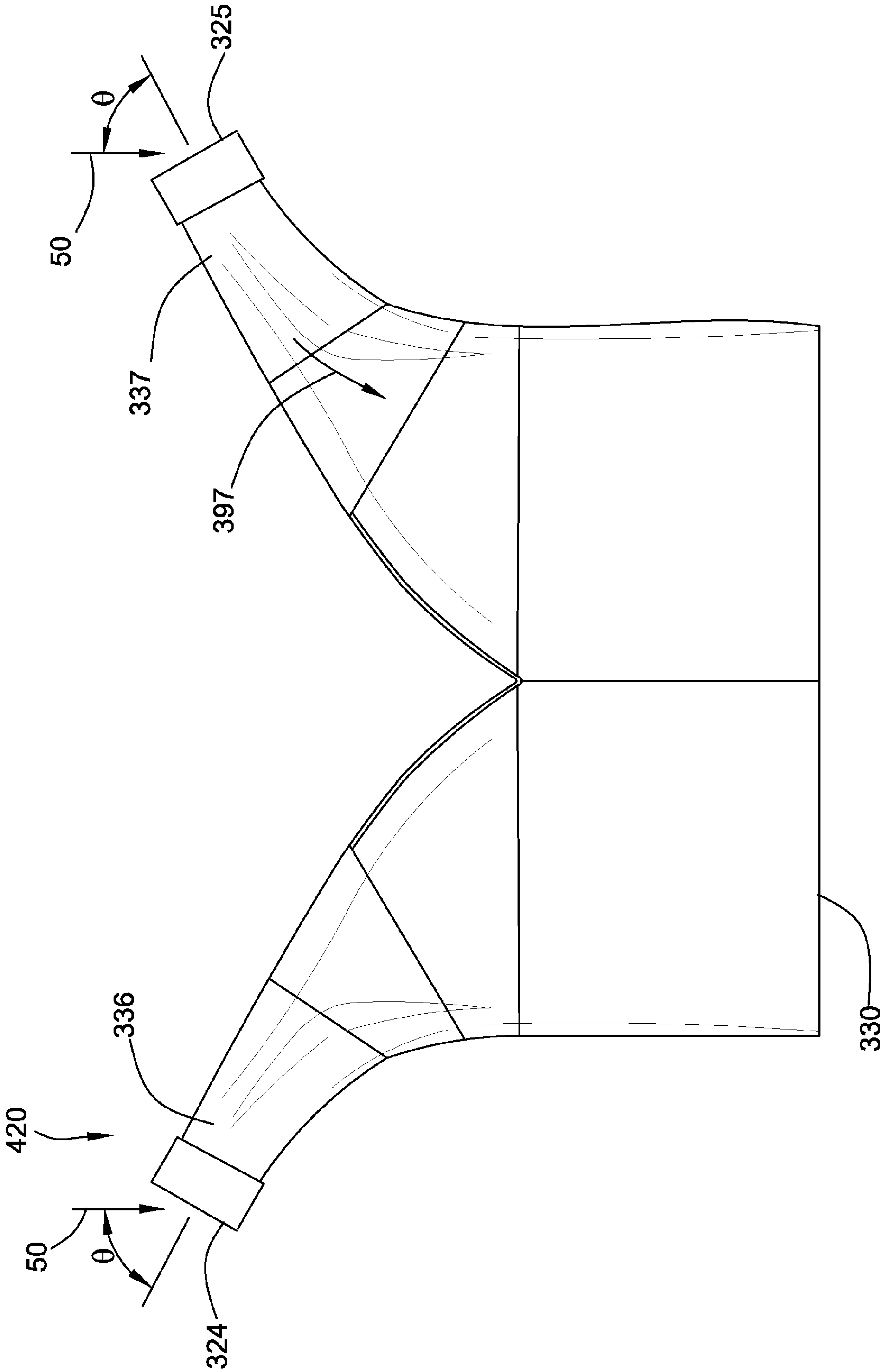

FIG. 16

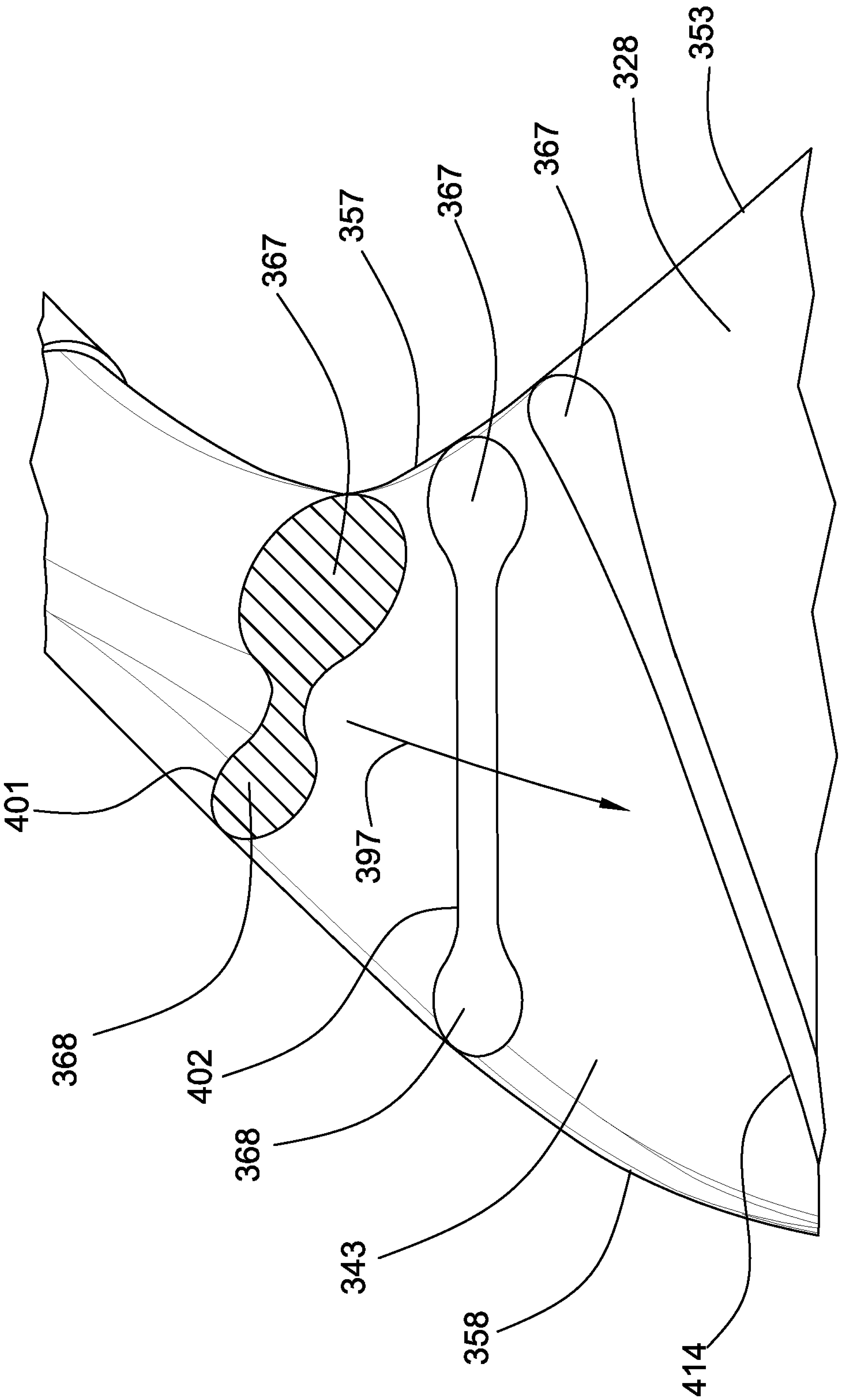

FIG. 17

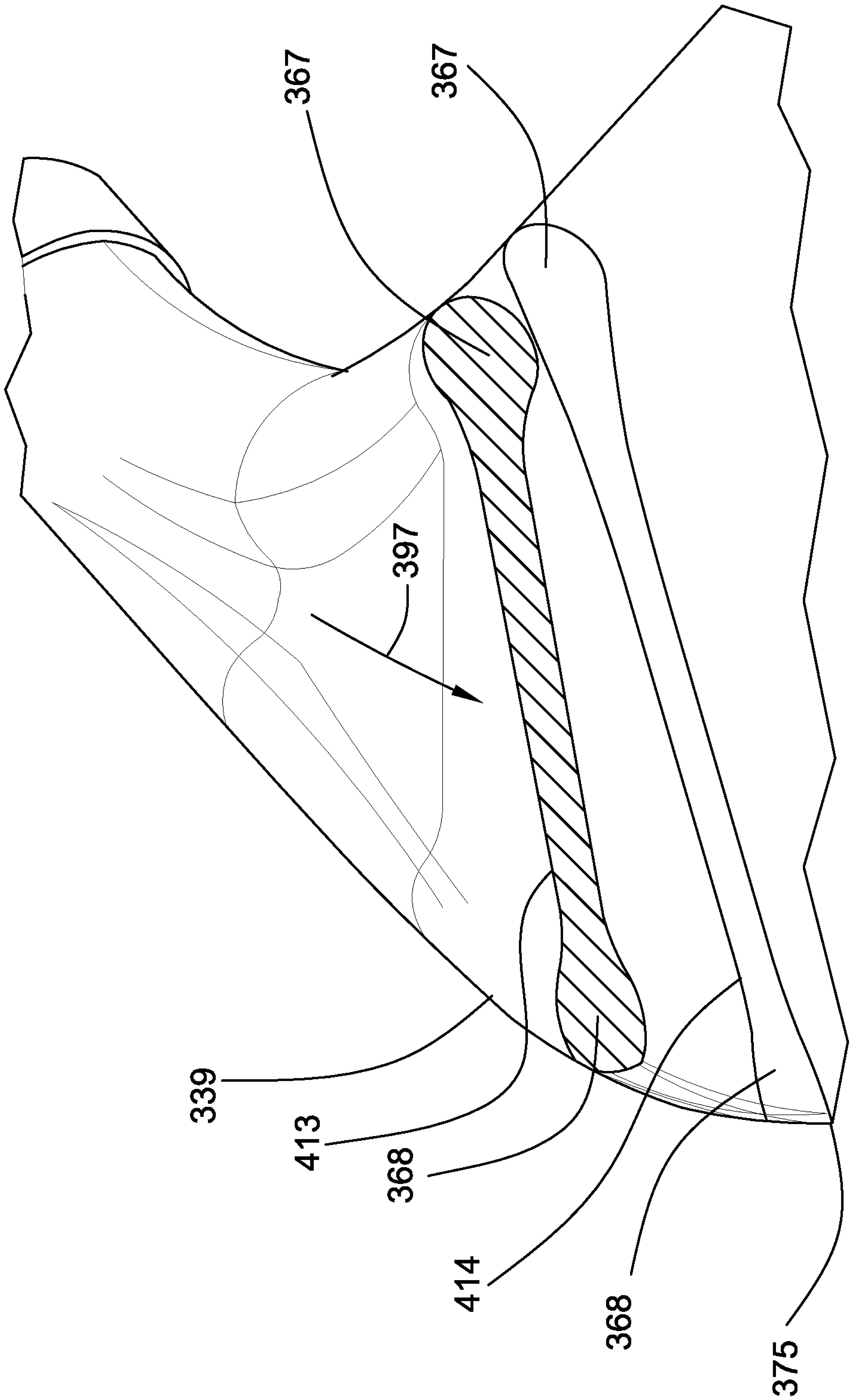

FIG. 18

FIG. 19

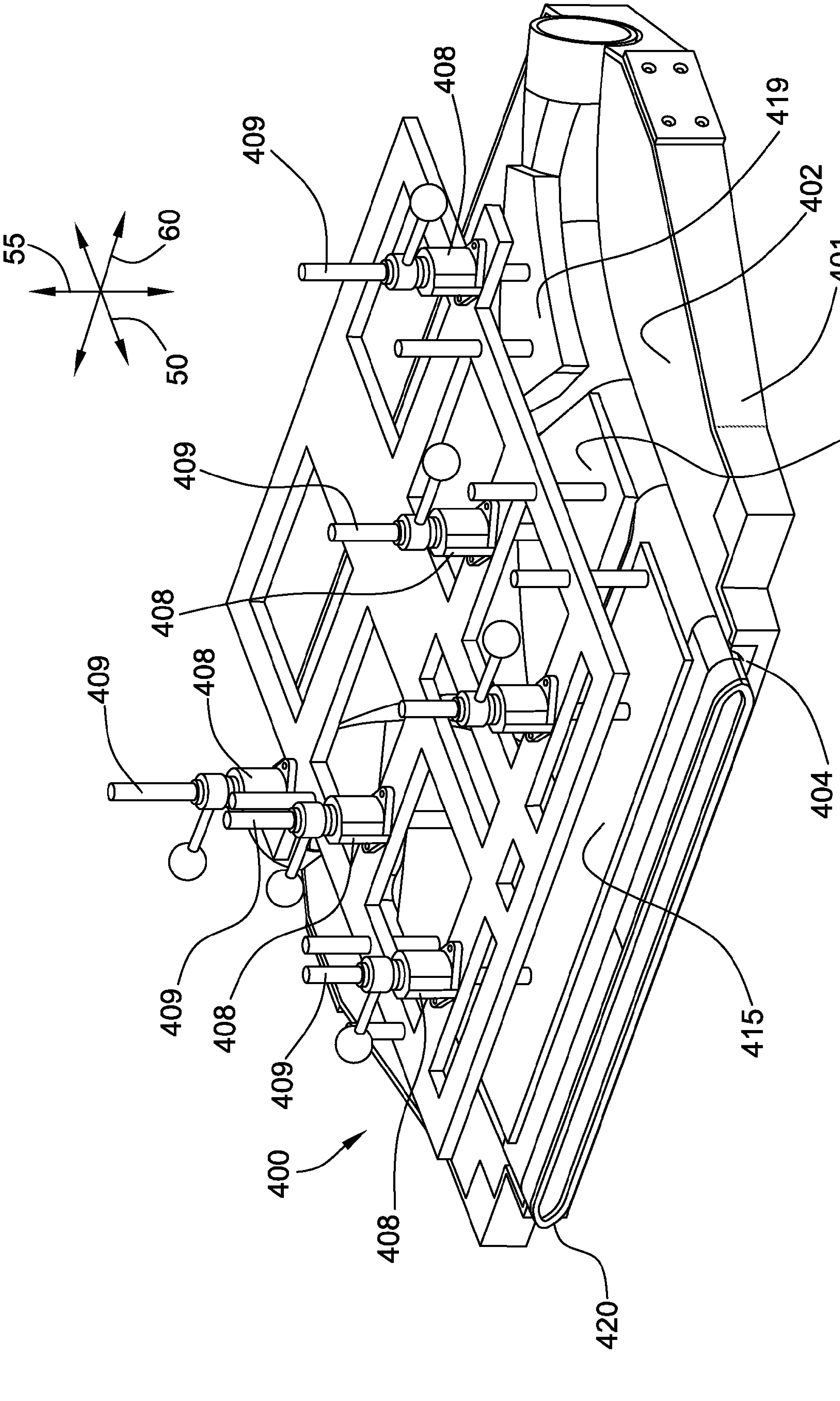
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FIG. 20

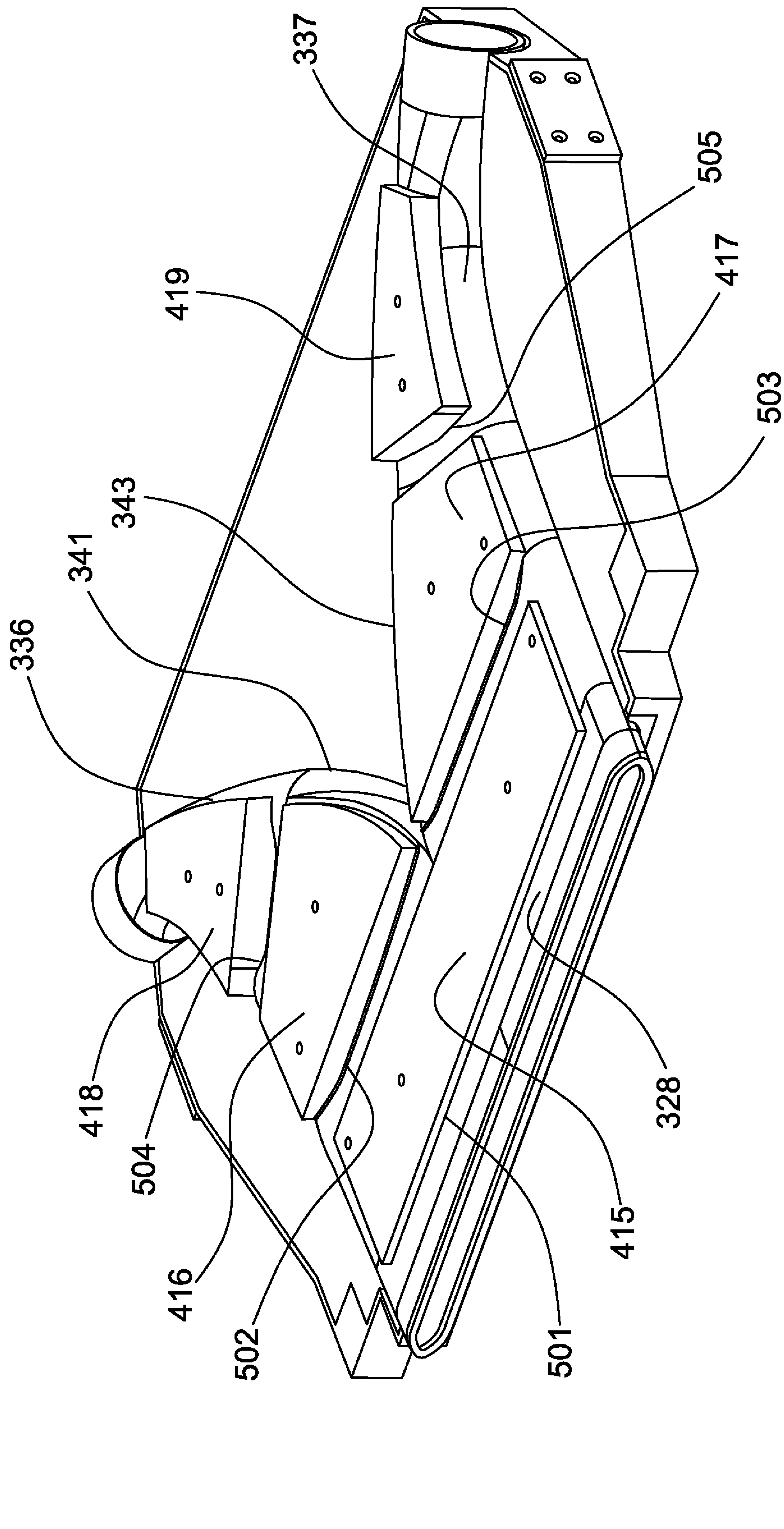

FIG. 21

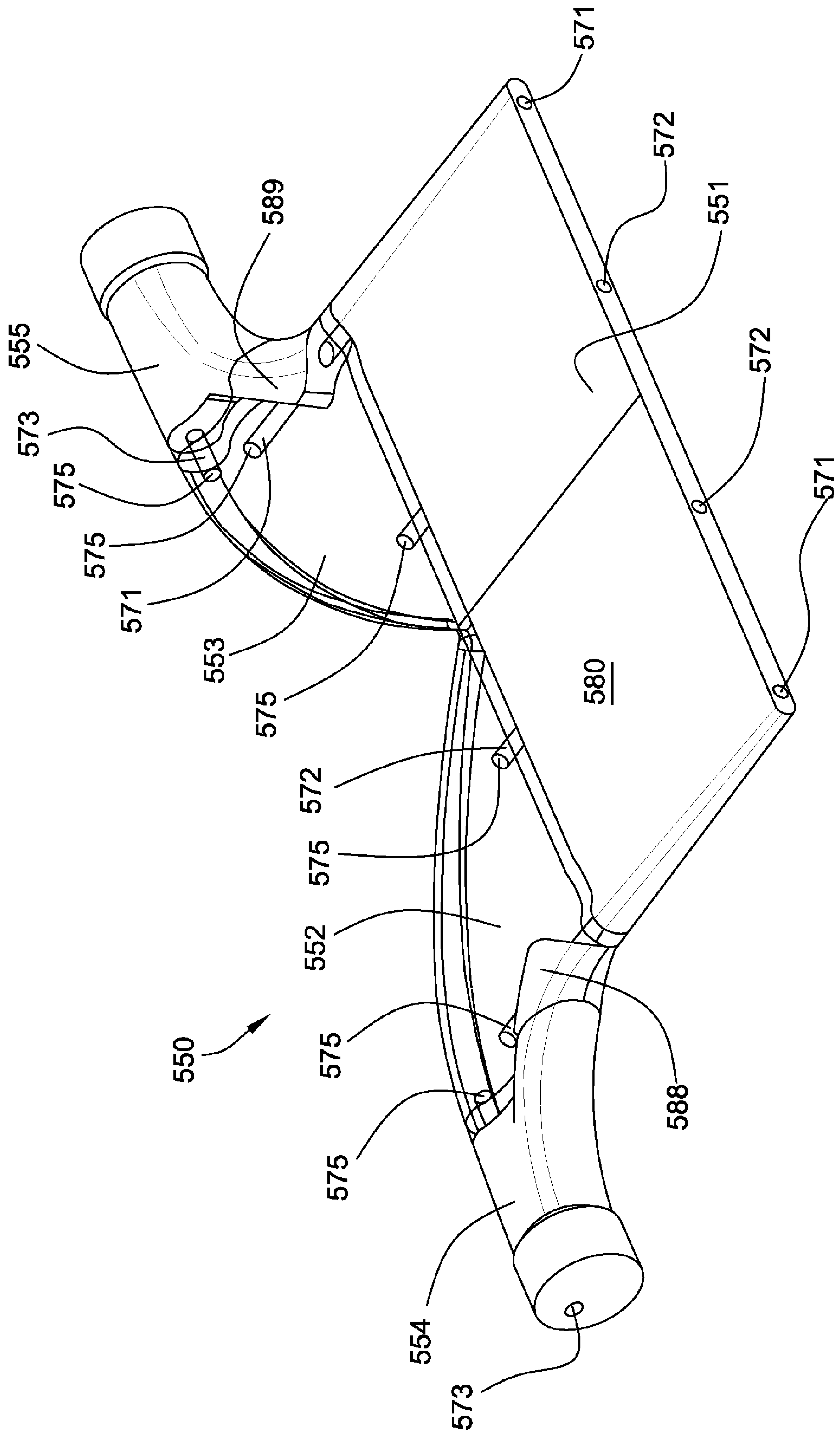
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FIG. 22

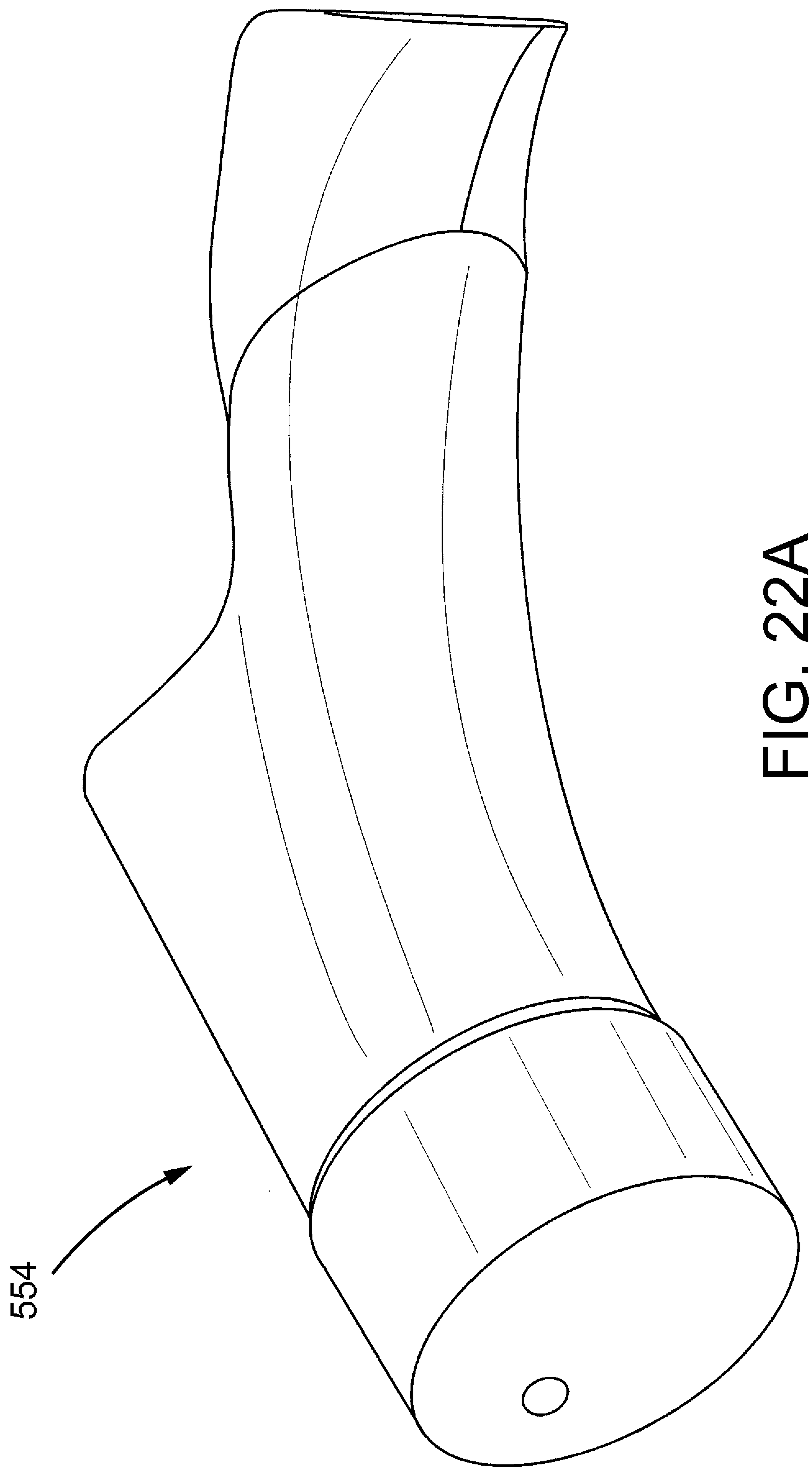


FIG. 22A

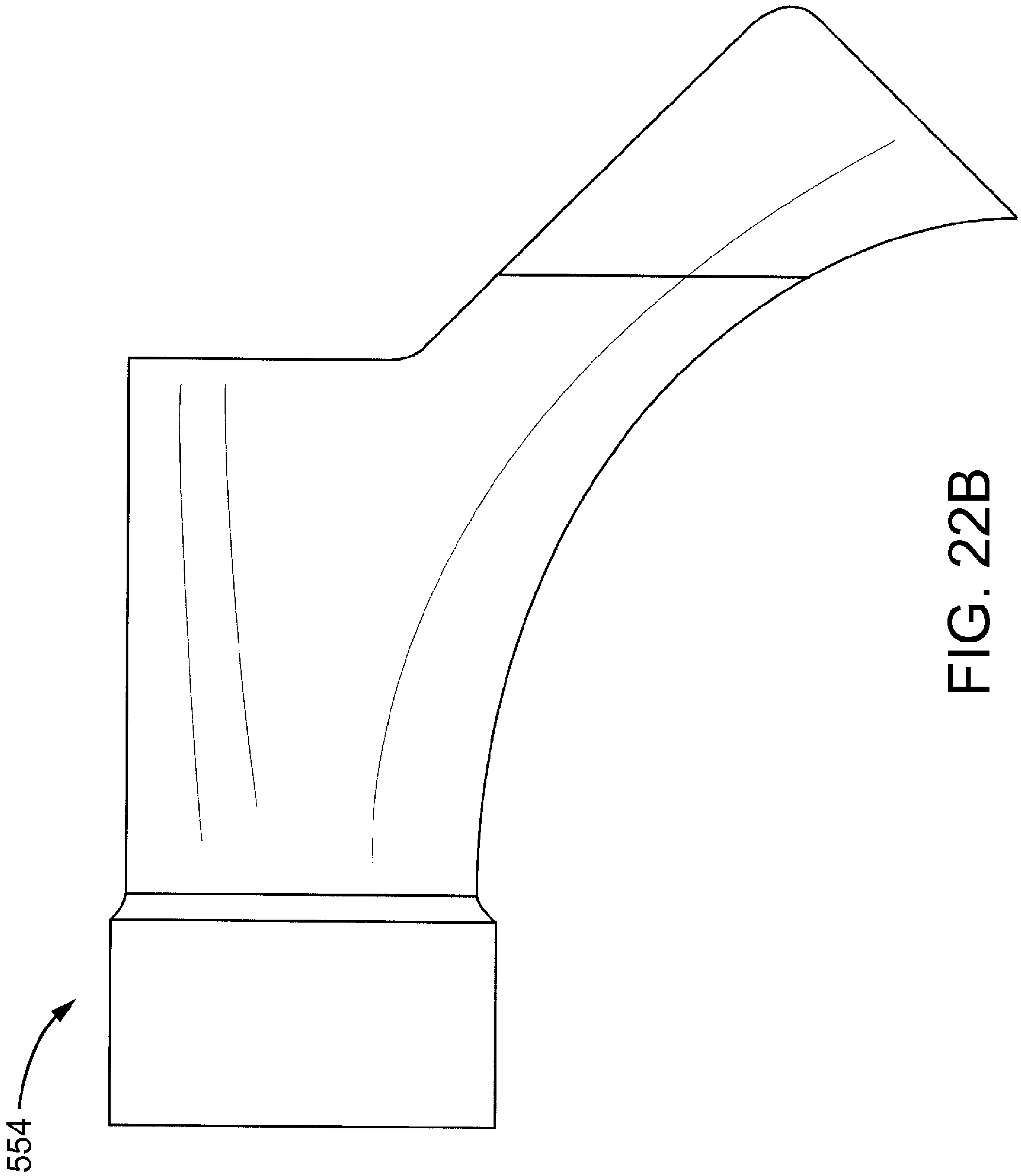


FIG. 22B

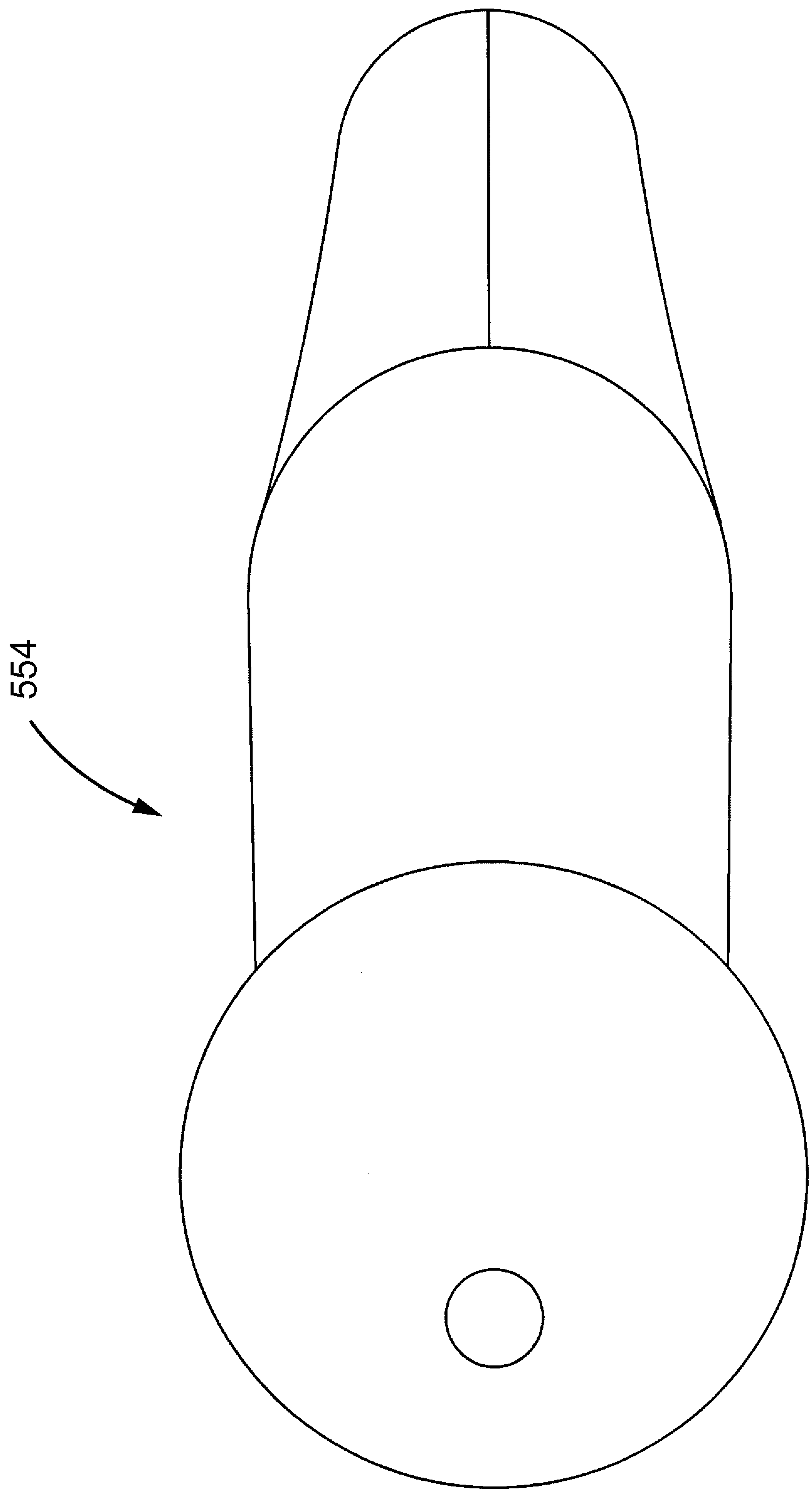


FIG. 22C

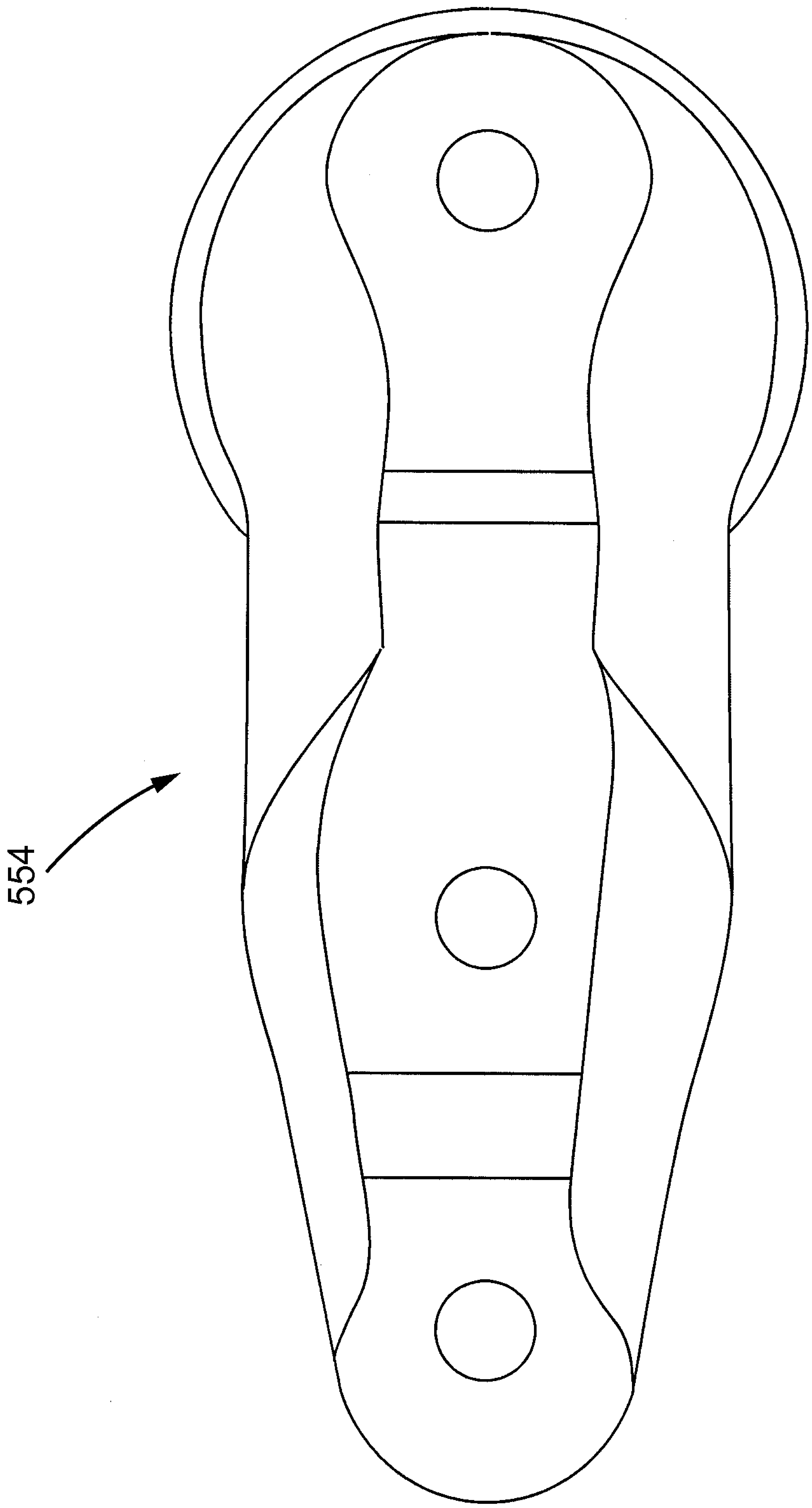


FIG. 22D

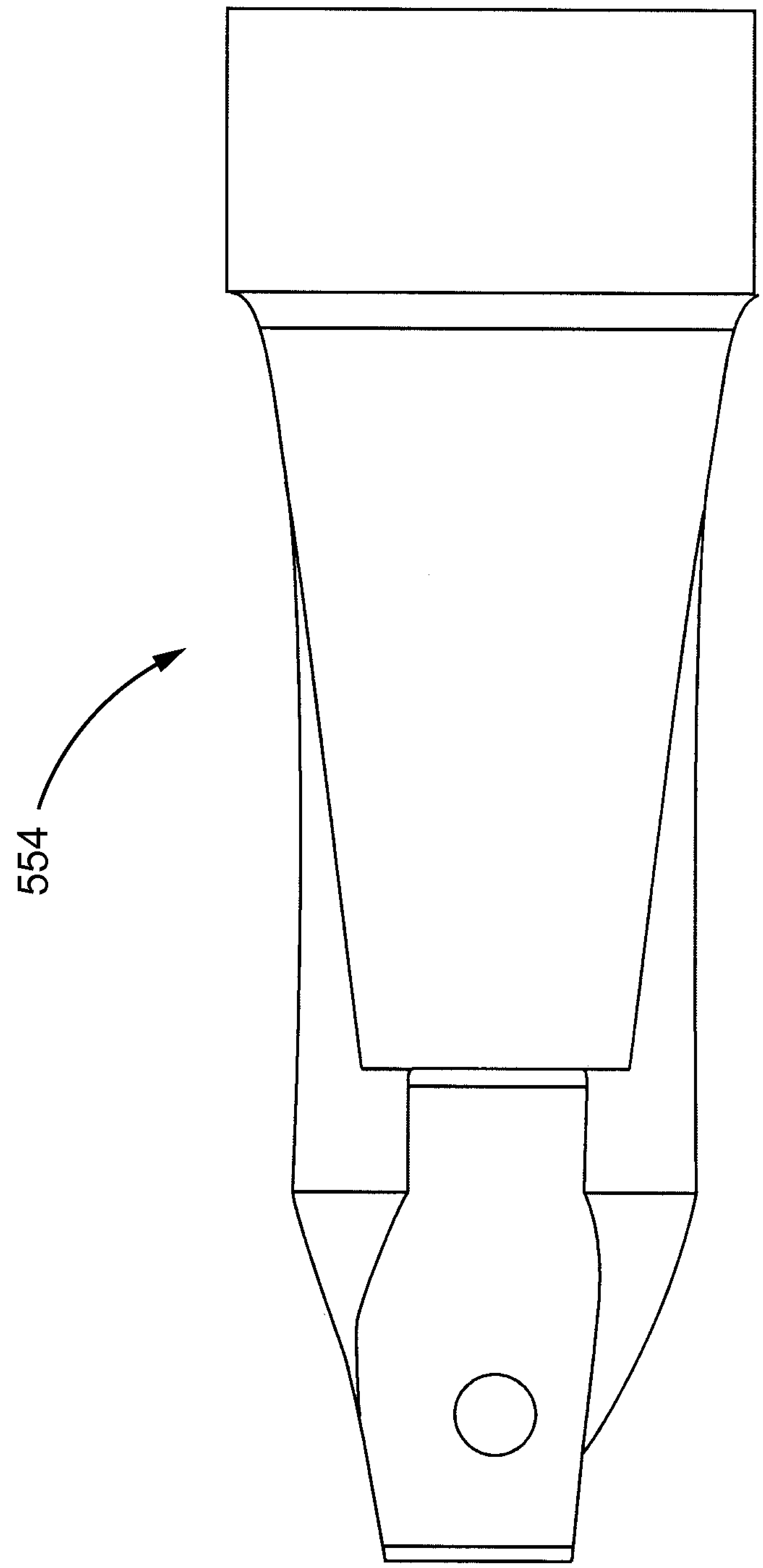


FIG. 22E

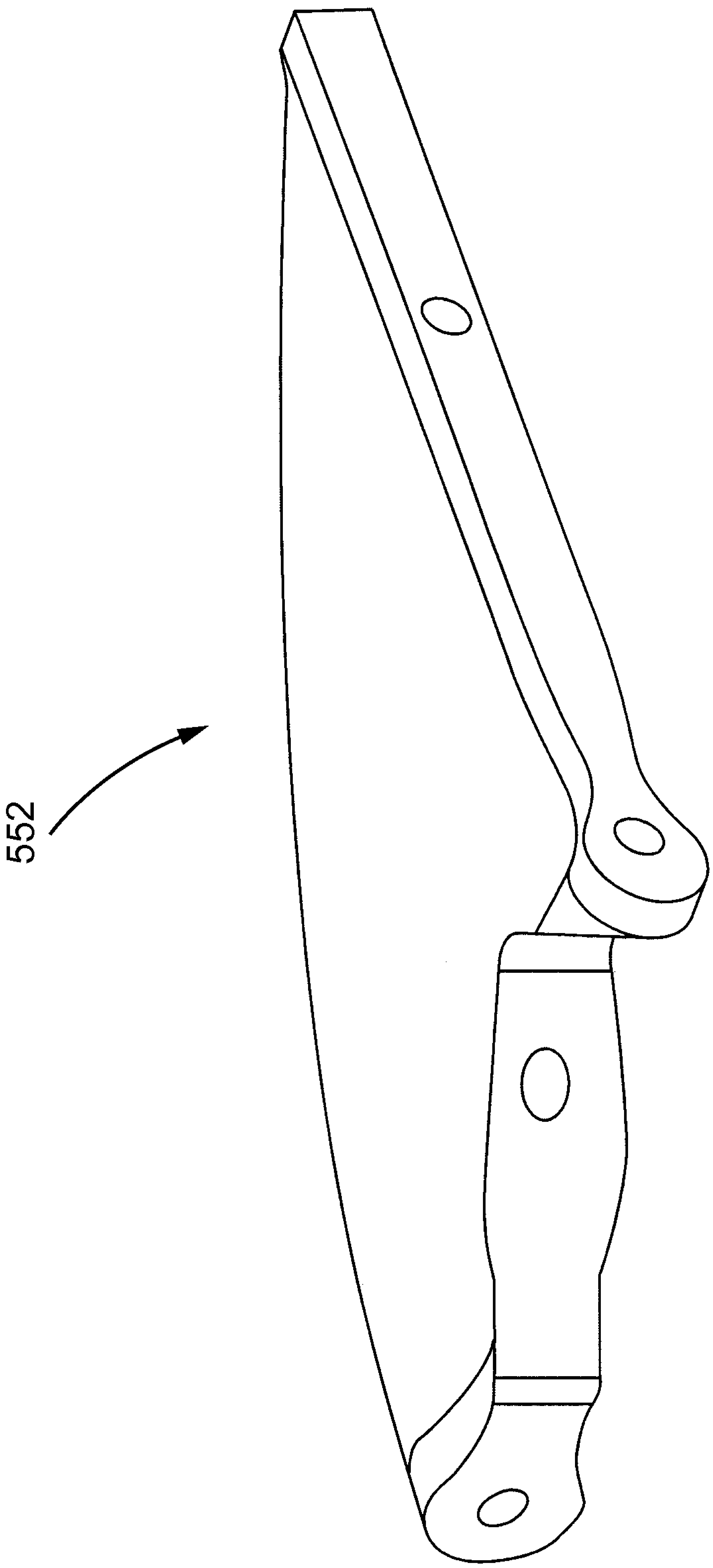


FIG. 22F

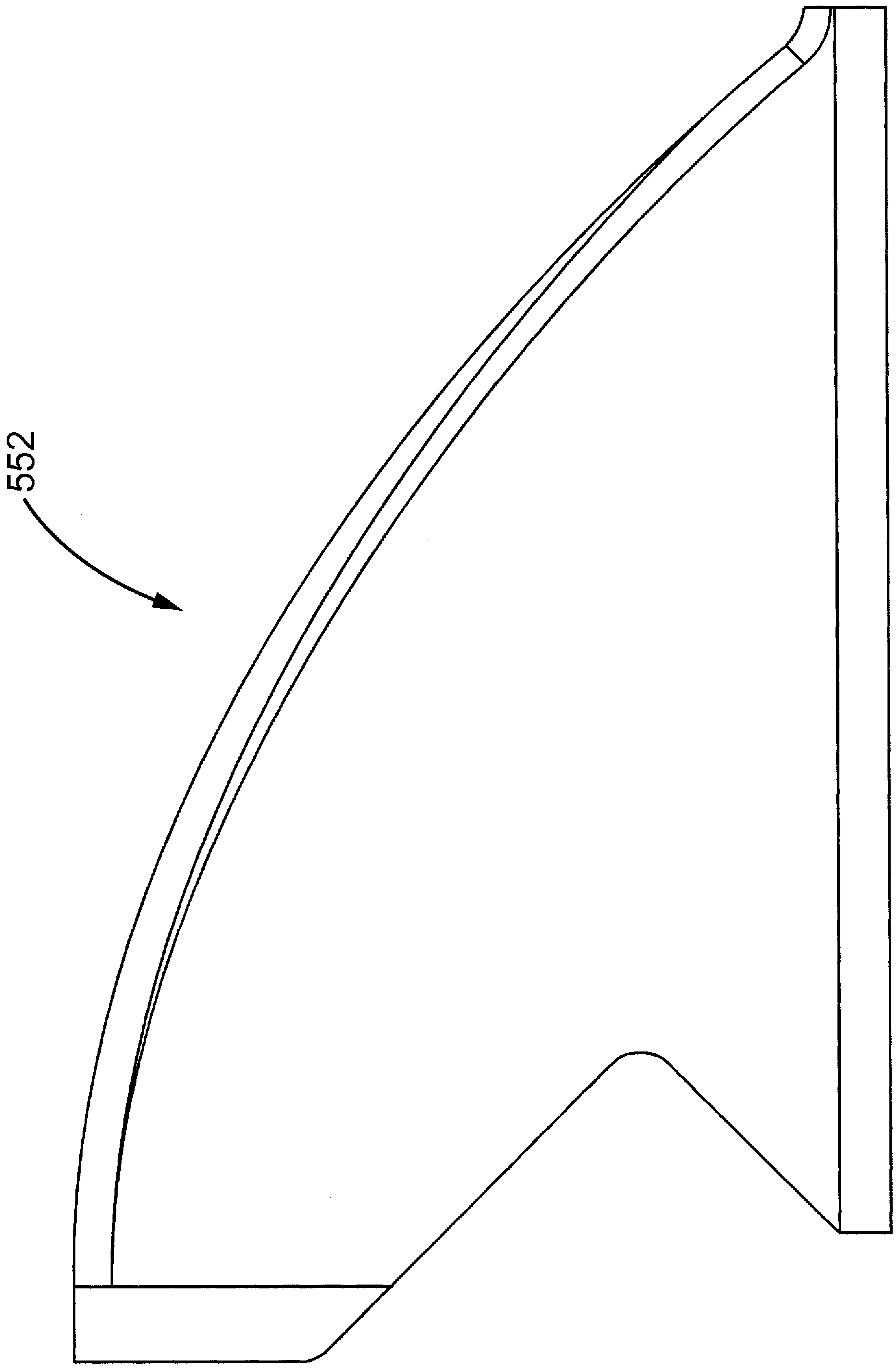


FIG. 22G

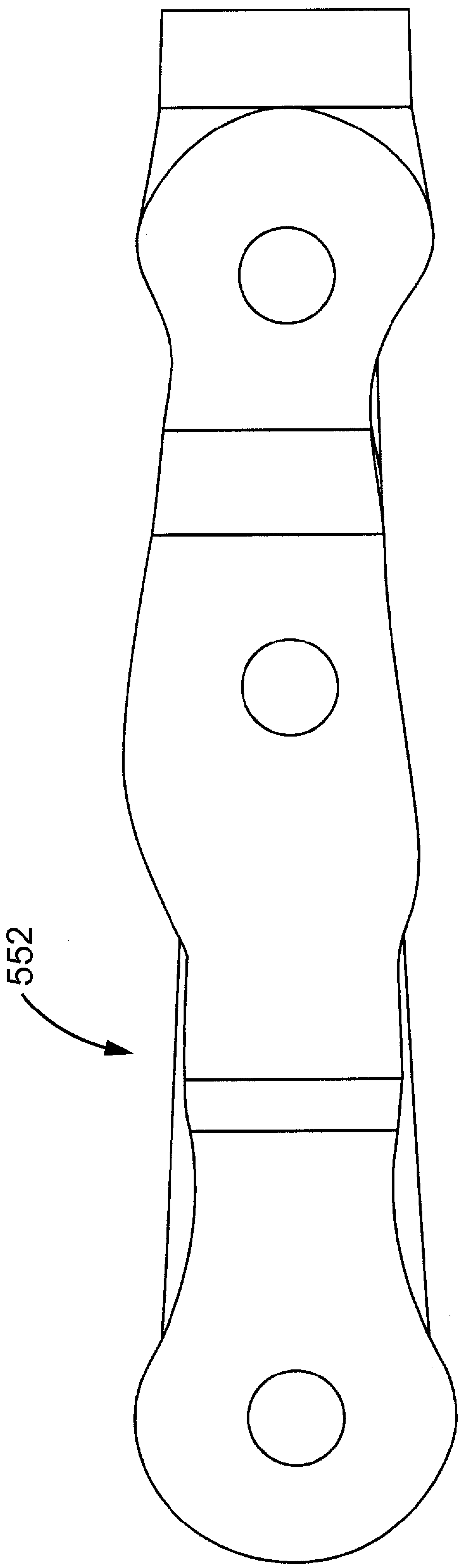


FIG. 22H

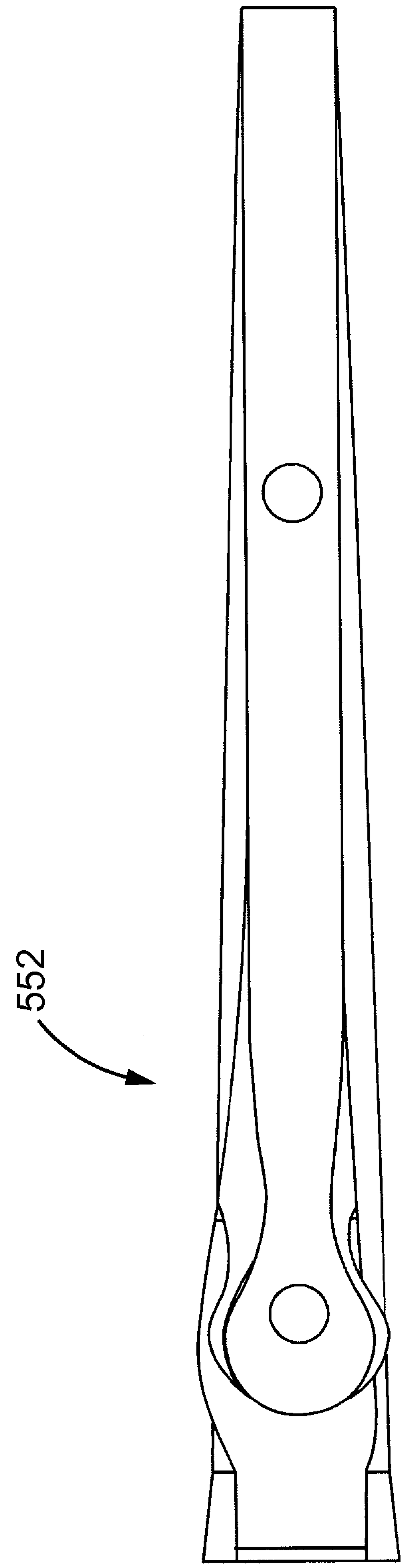


FIG. 22I

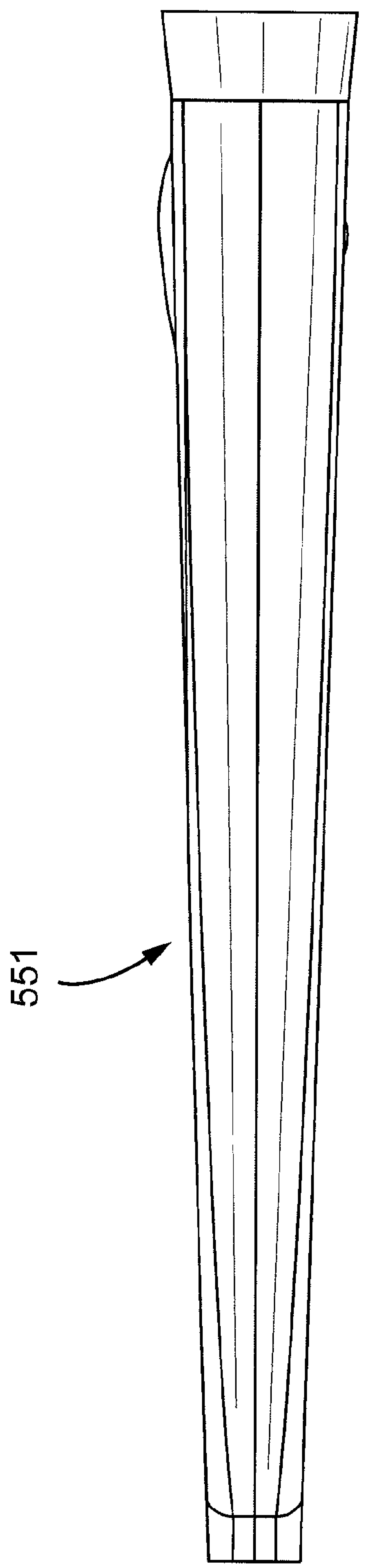


FIG. 22J

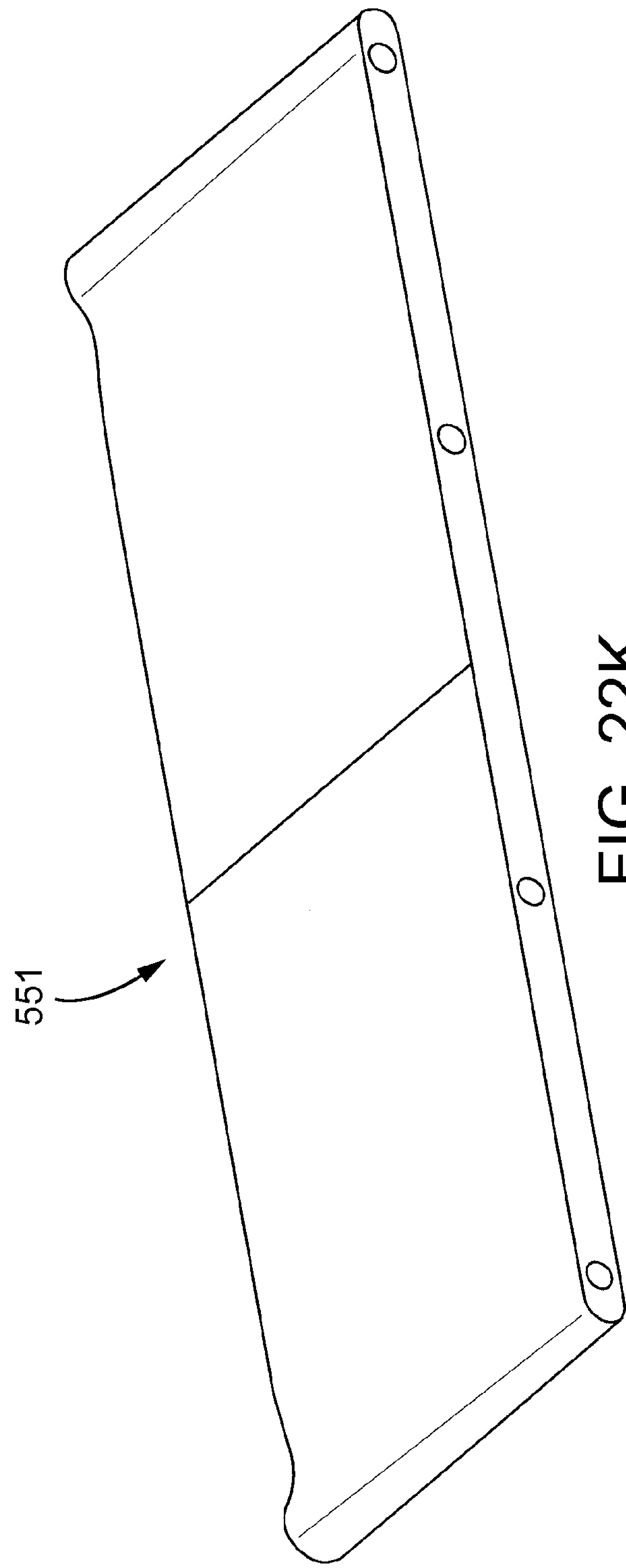
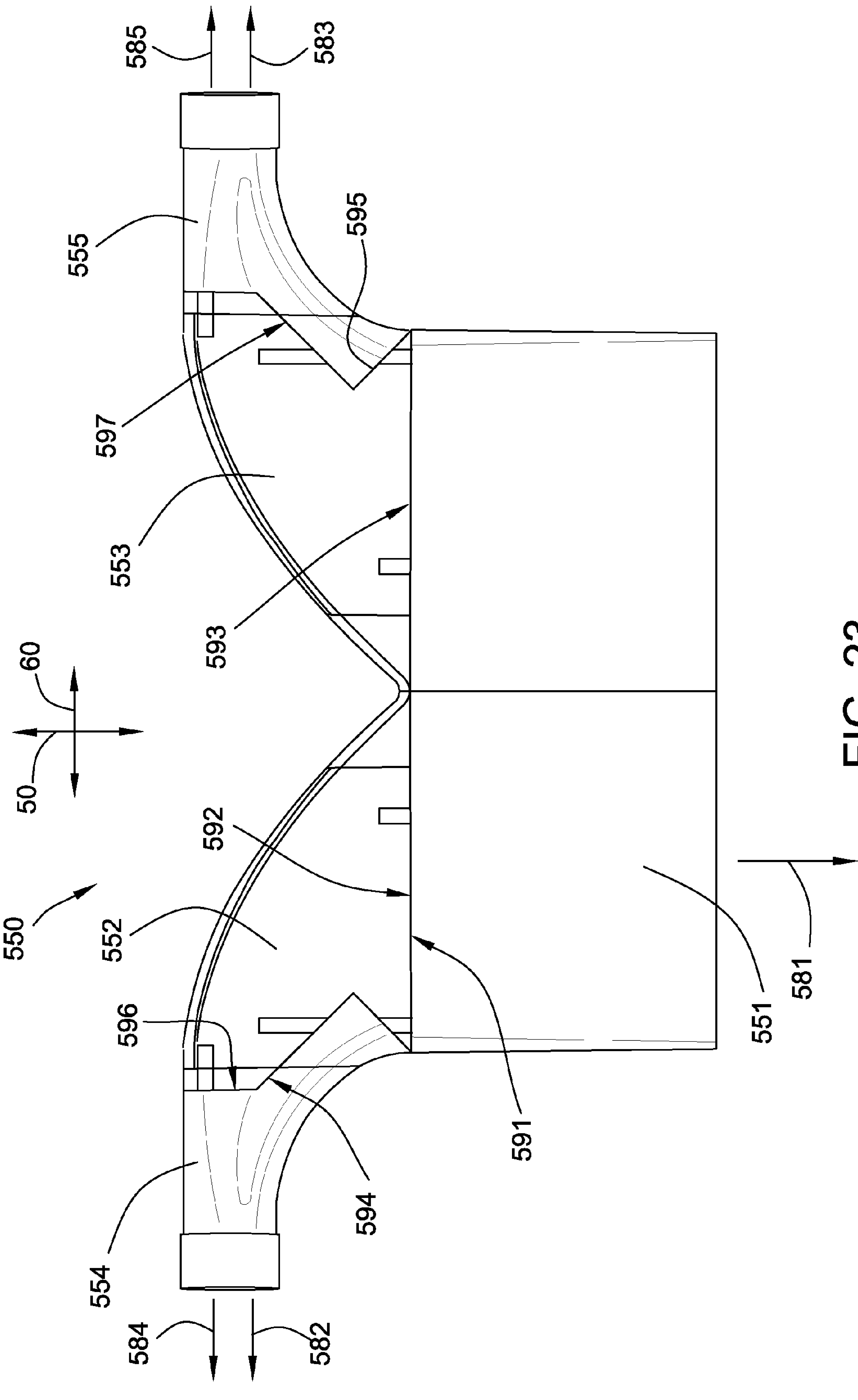


FIG. 22K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583
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584
582

FIG. 23

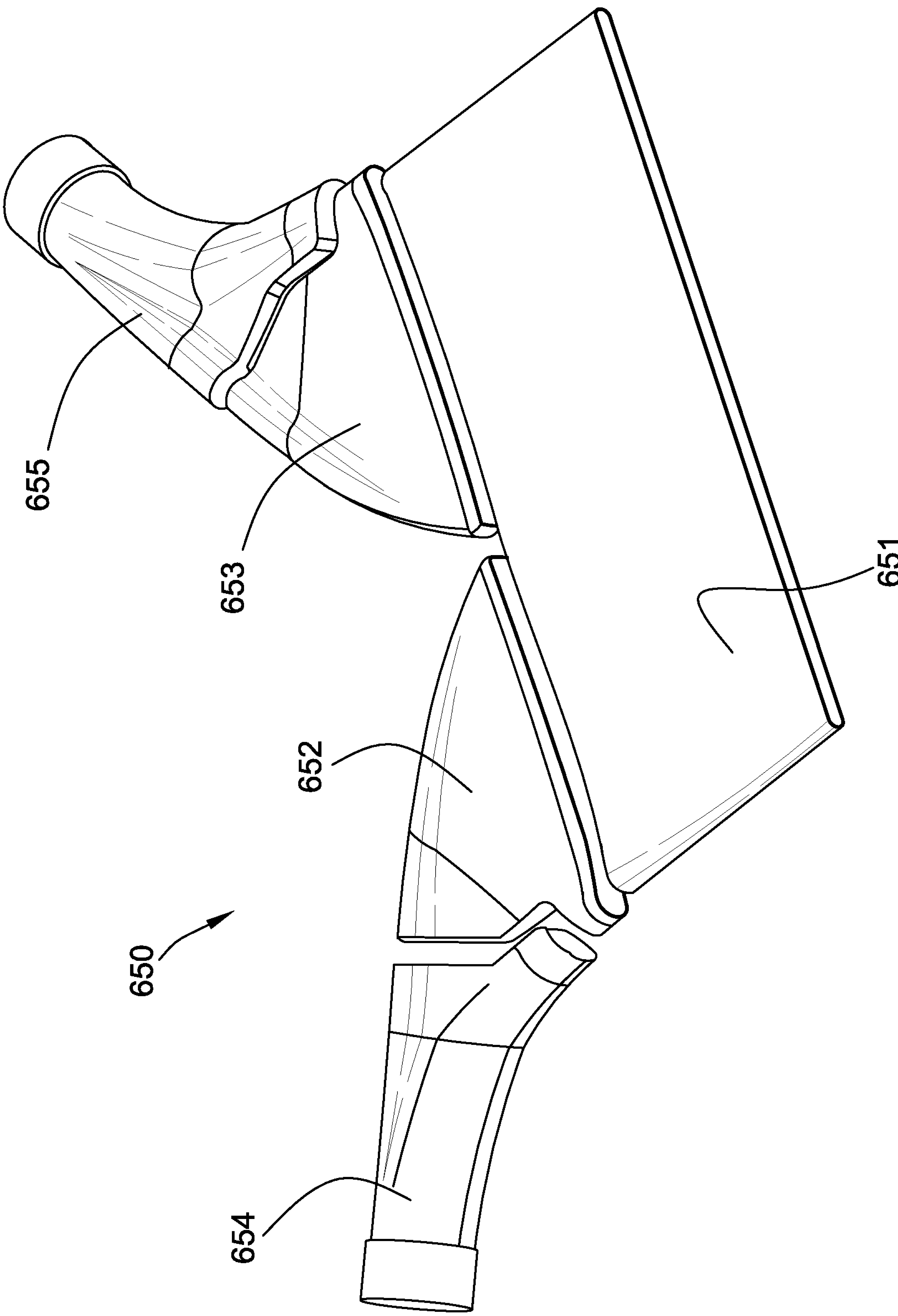


FIG. 24

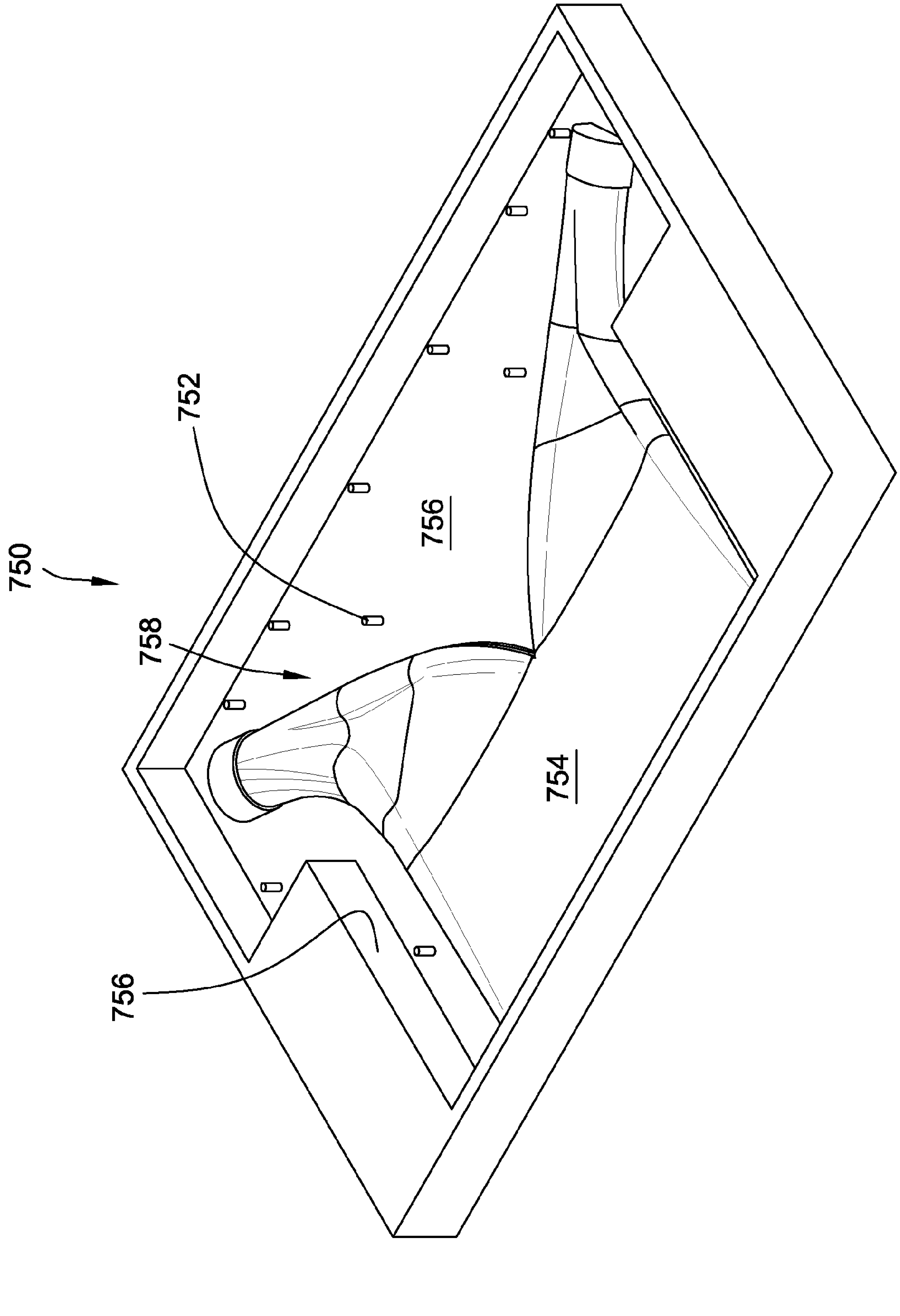


FIG. 25

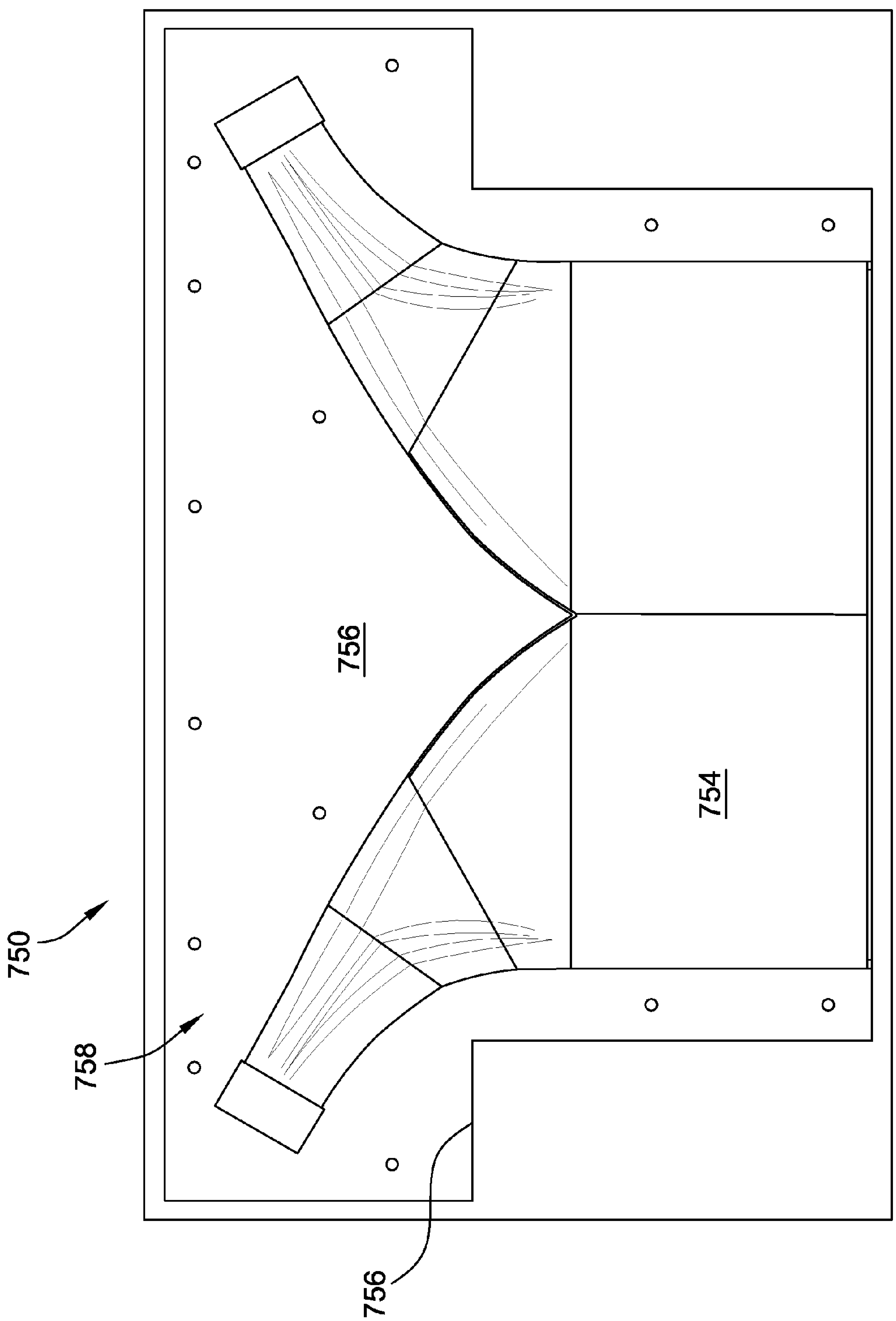
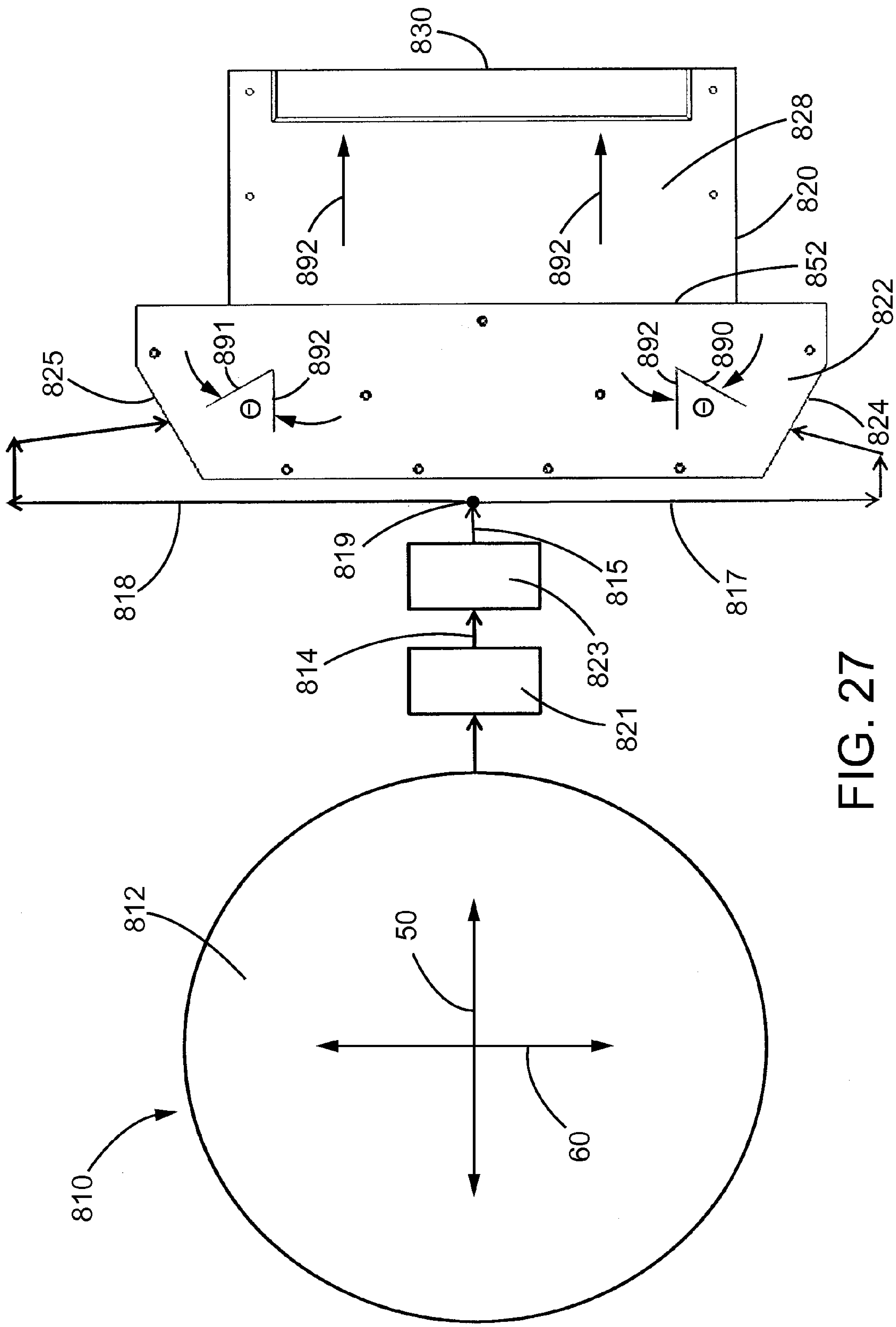


FIG. 26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852
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823
821
812
50
60
810

FIG. 27

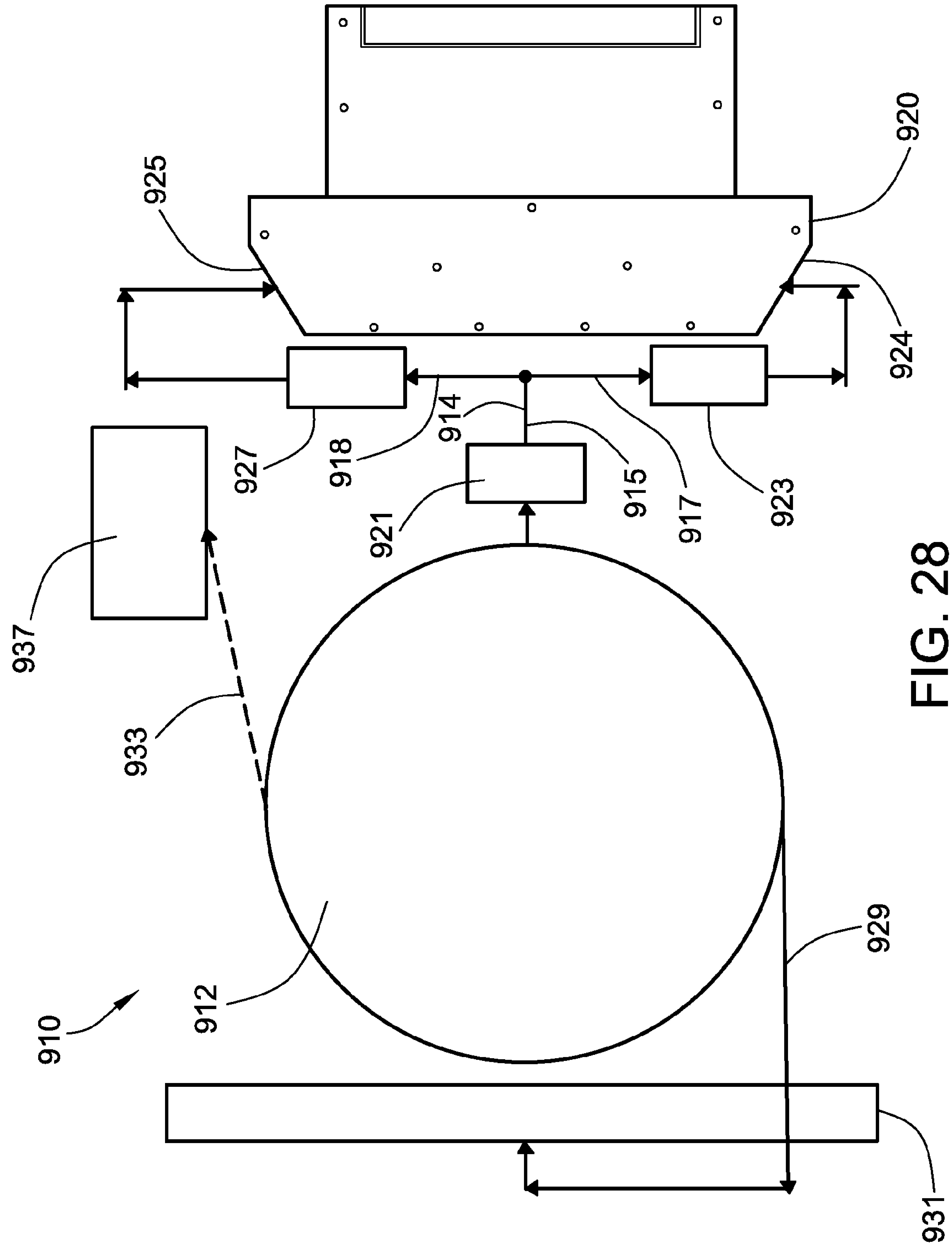
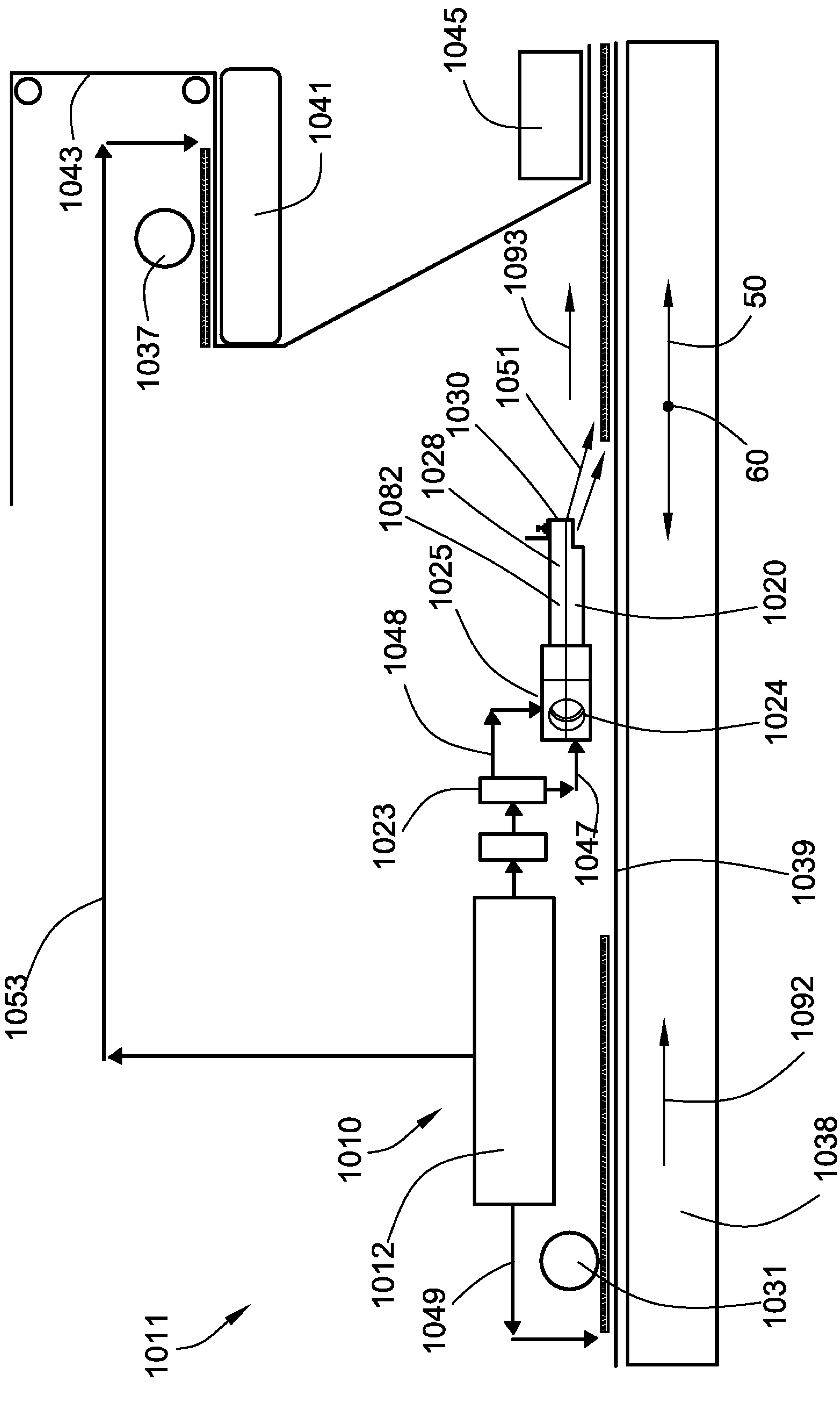


FIG. 28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1041
1037
1093
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1051
1030
1028
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1082
1025
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1048
1024
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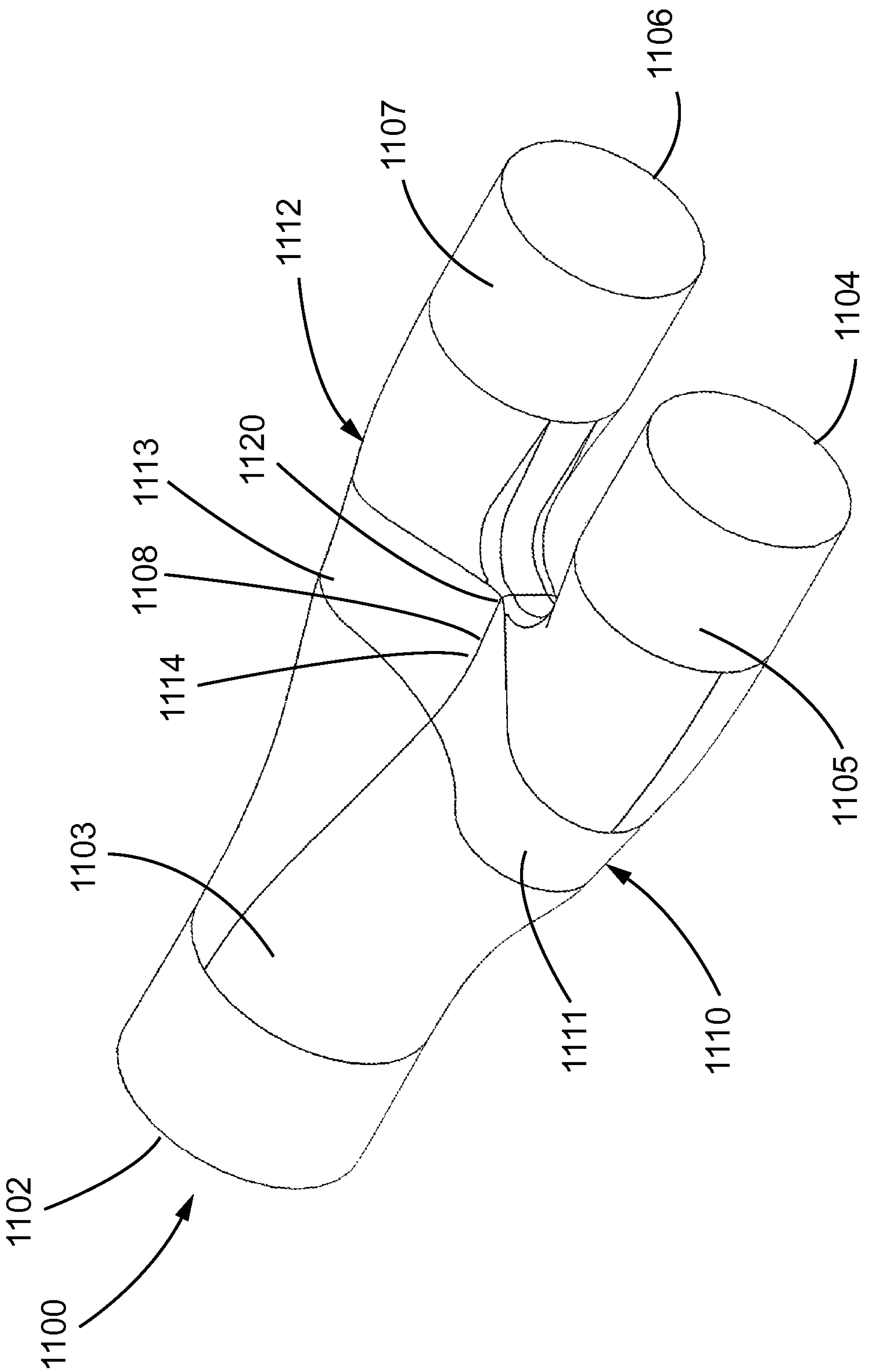
1047
1039
1053
1092
1010
1038
1012
1031
1049
1011

FIG. 29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1113
1108
1114
1105
1103
1111
1110
1102
1100

FIG. 30

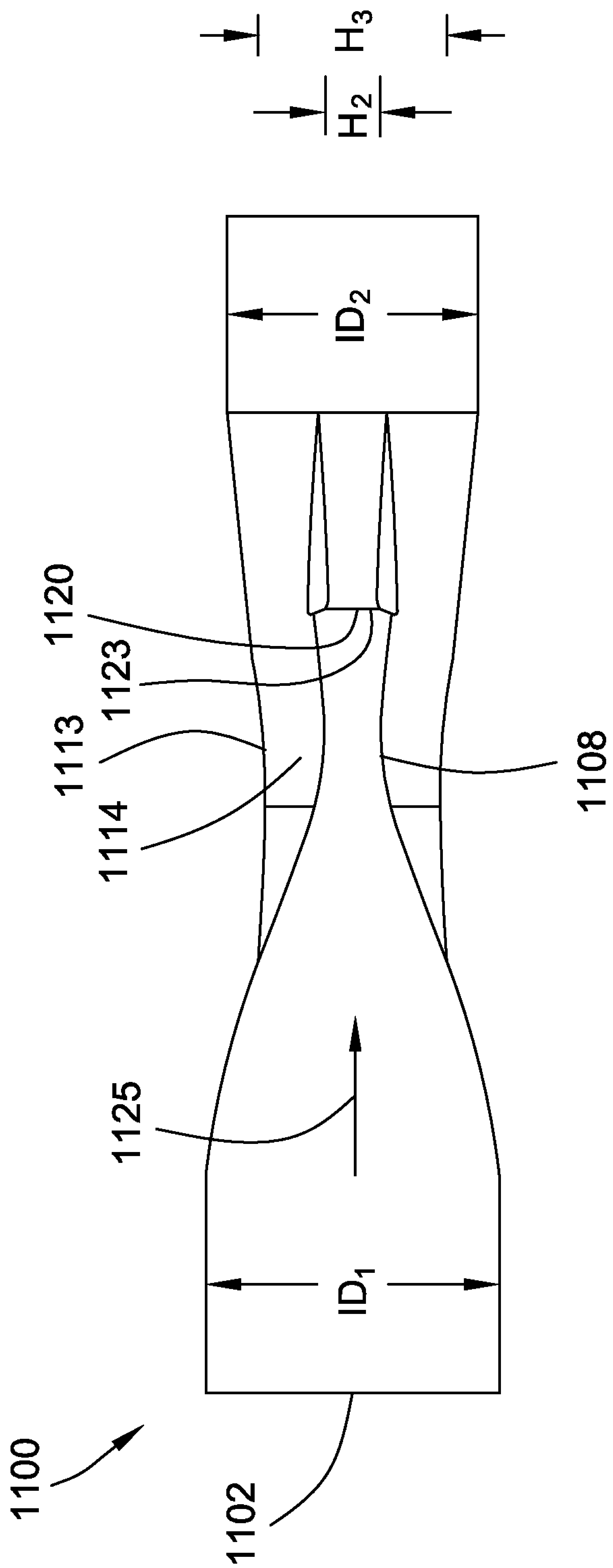


FIG. 31

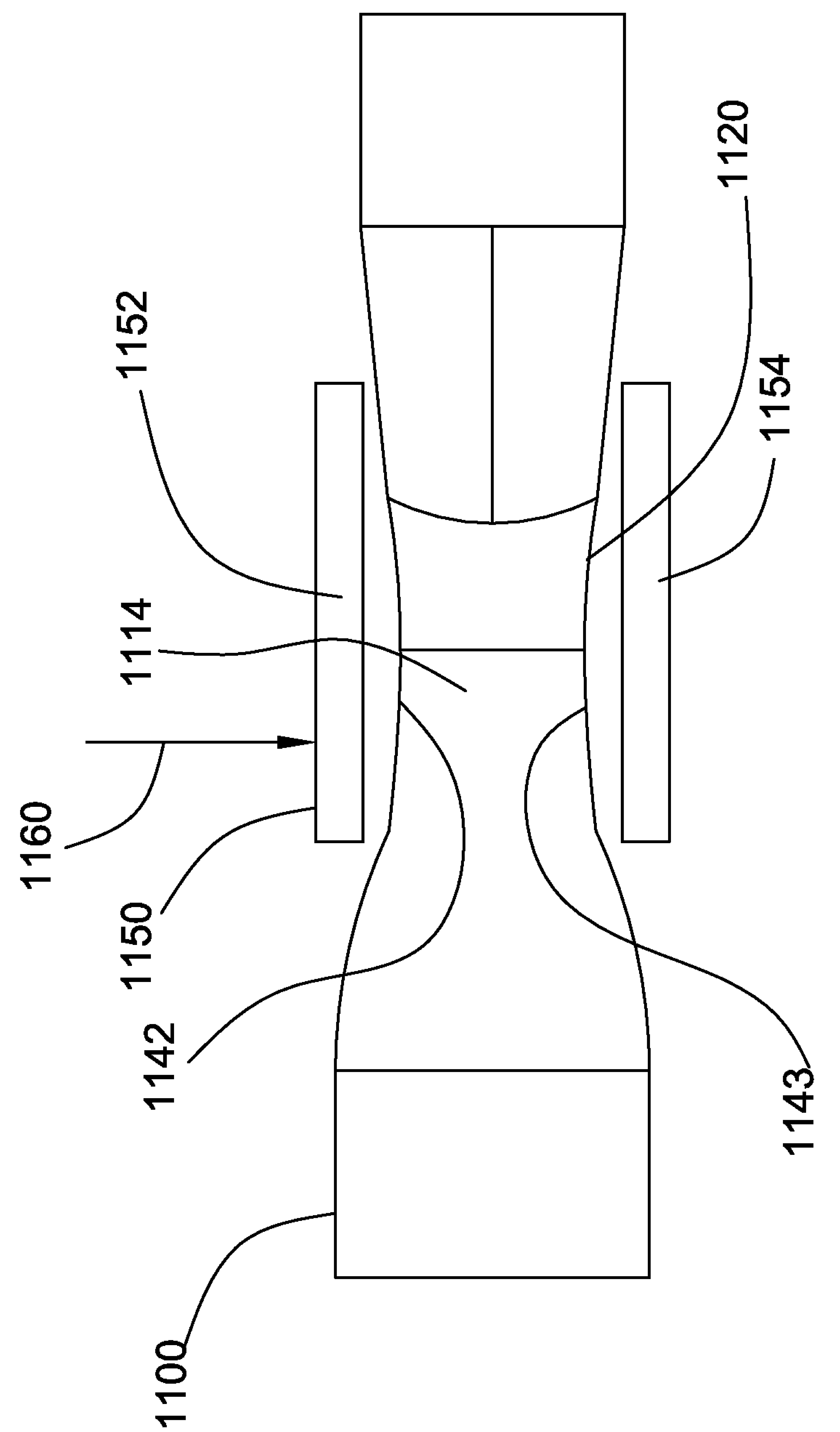


FIG. 32

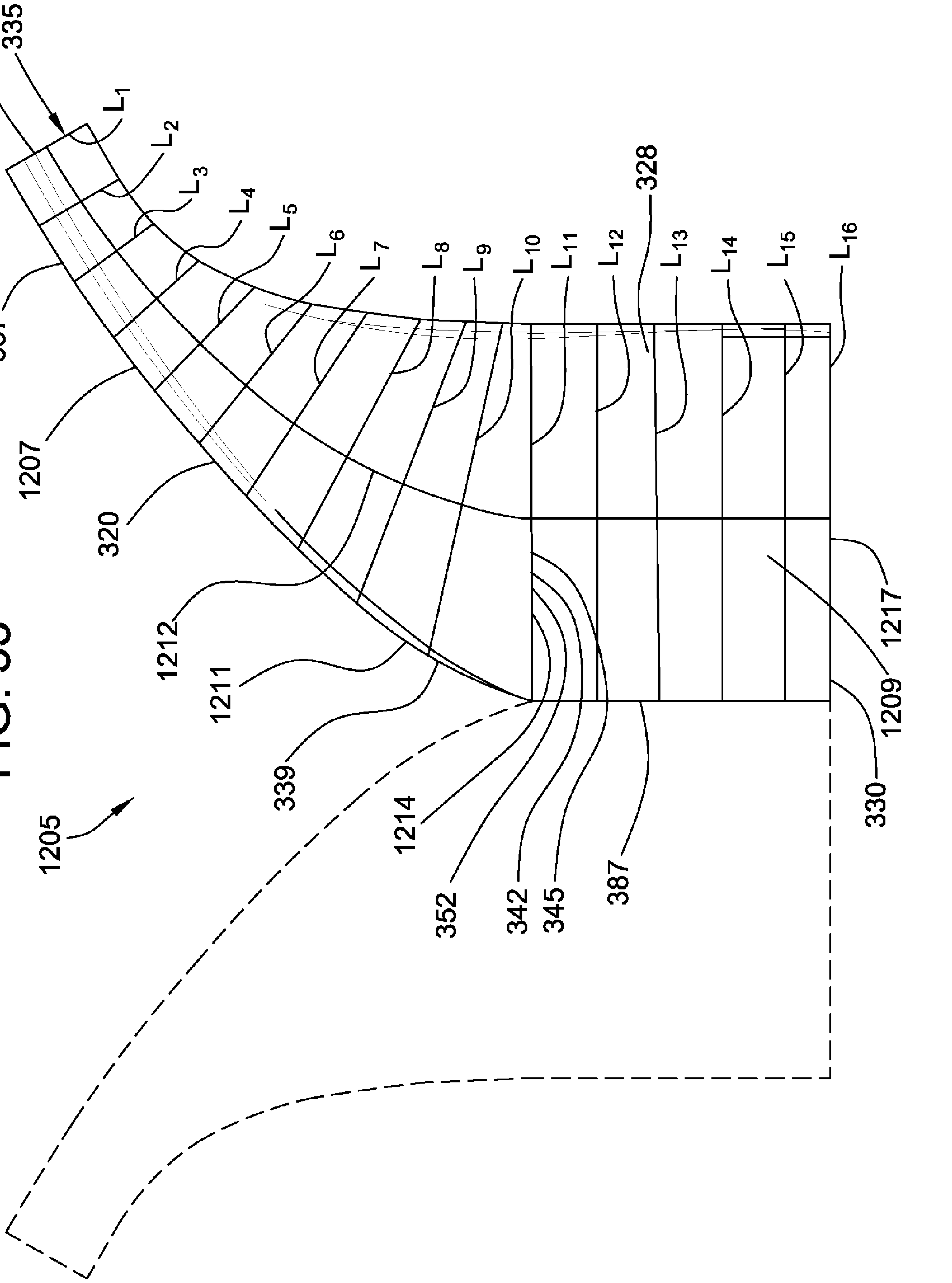

325
335
L1
L2
L3
L4
L5
L6
L7
L8
L9
L10
L11
L12
L13
L14
L15
L16
328
337
1207
320
1212
1211
339
1205
1214
352
342
345
387
330
1209
1217

FIG. 33

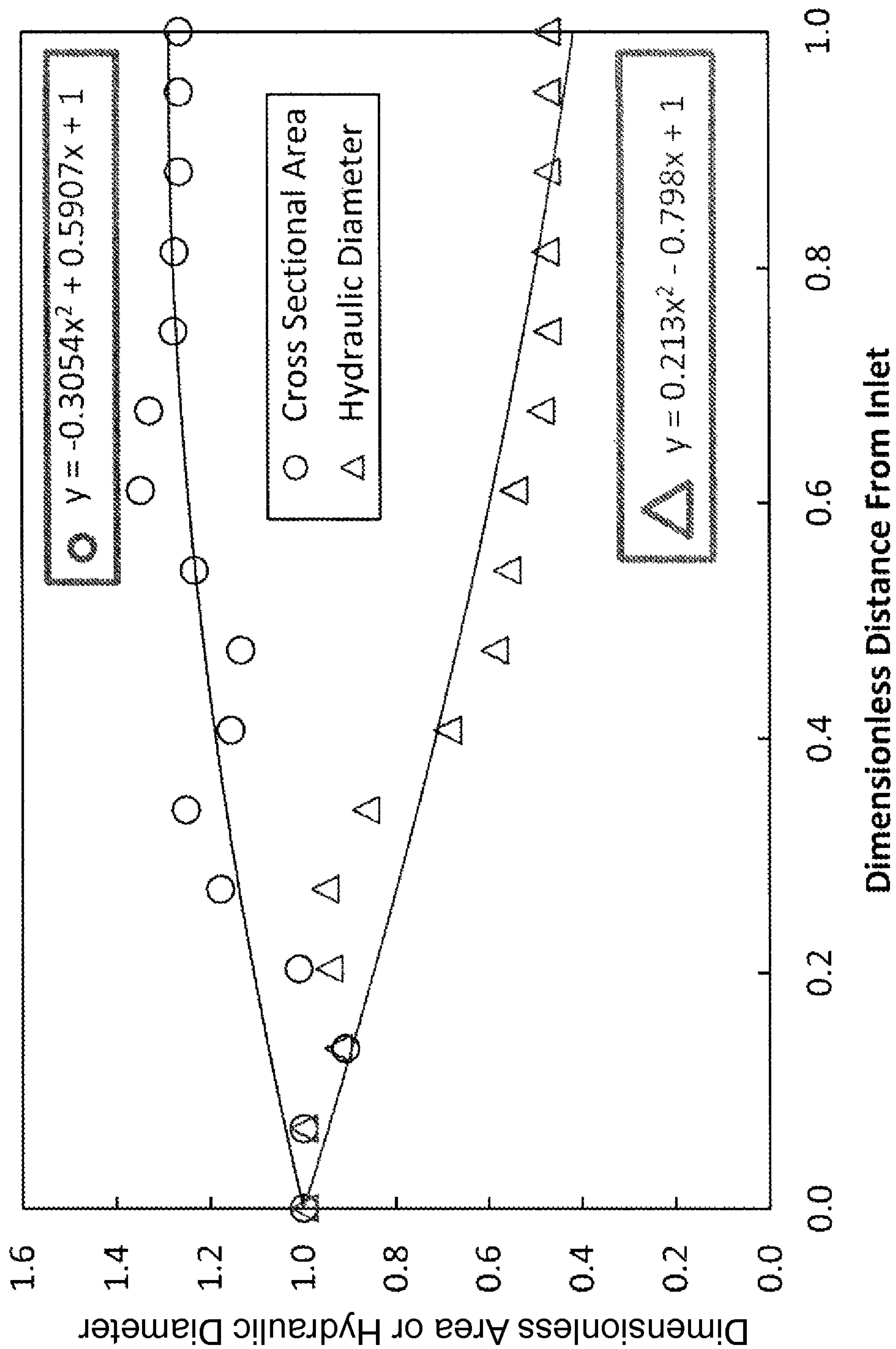

y = -0.3054x² + 0.5907x + 1
Cross Sectional Area
Hydraulic Diameter
y = 0.213x² - 0.798x + 1
Dimensionless Area or Hydraulic Diameter
Dimensionless Distance From Inlet
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6

FIG. 34

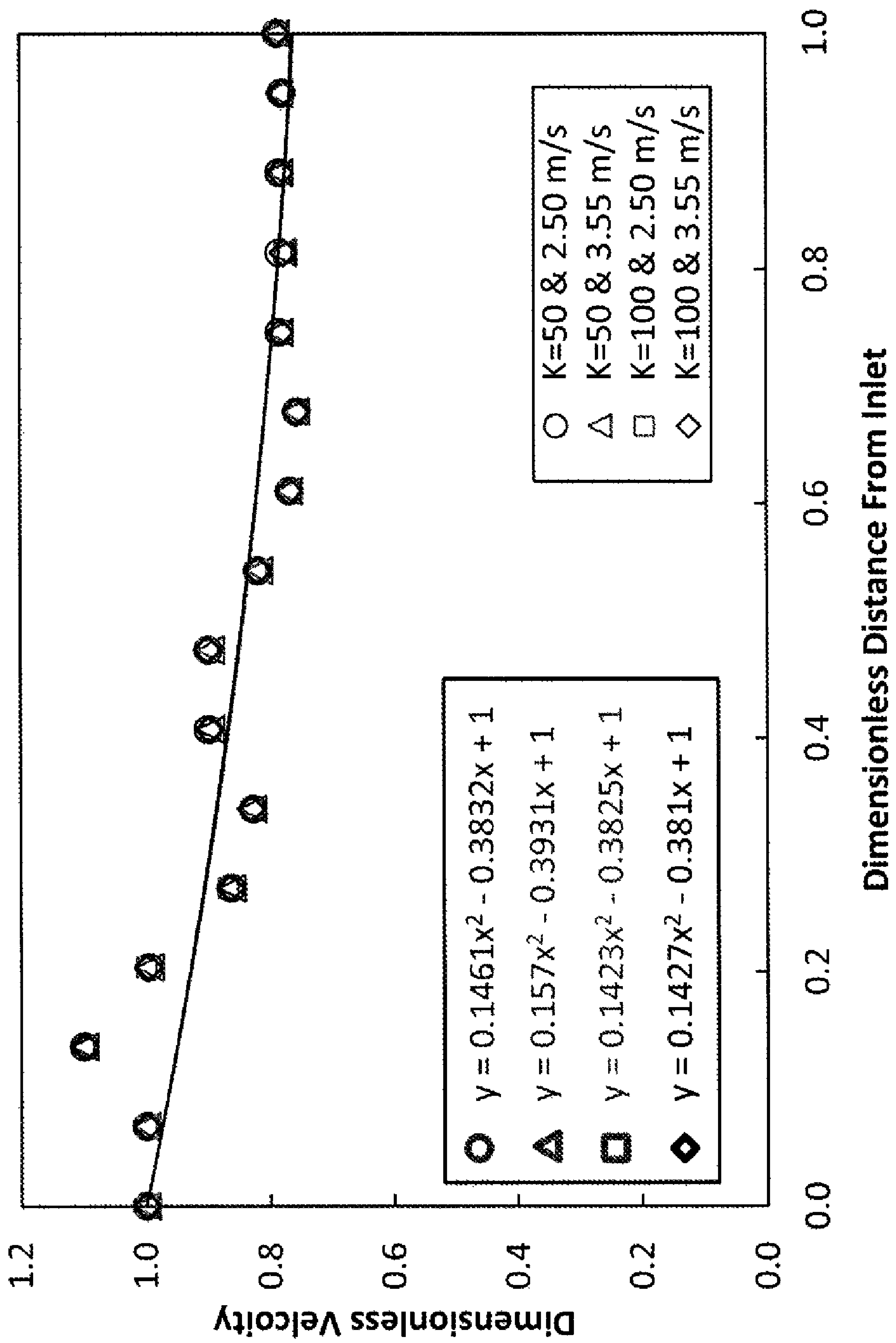

Dimensionless Velocity
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0.0
0.2
0.4
0.6
0.8
1.0
Dimensionless Distance From Inlet
y = 0.1461x² - 0.3832x + 1
y = 0.157x² - 0.3931x + 1
y = 0.1423x² - 0.3825x + 1
y = 0.1427x² - 0.381x + 1
K=50 & 2.50 m/s
K=50 & 3.55 m/s
K=100 & 2.50 m/s
K=100 & 3.55 m/s

FIG. 35

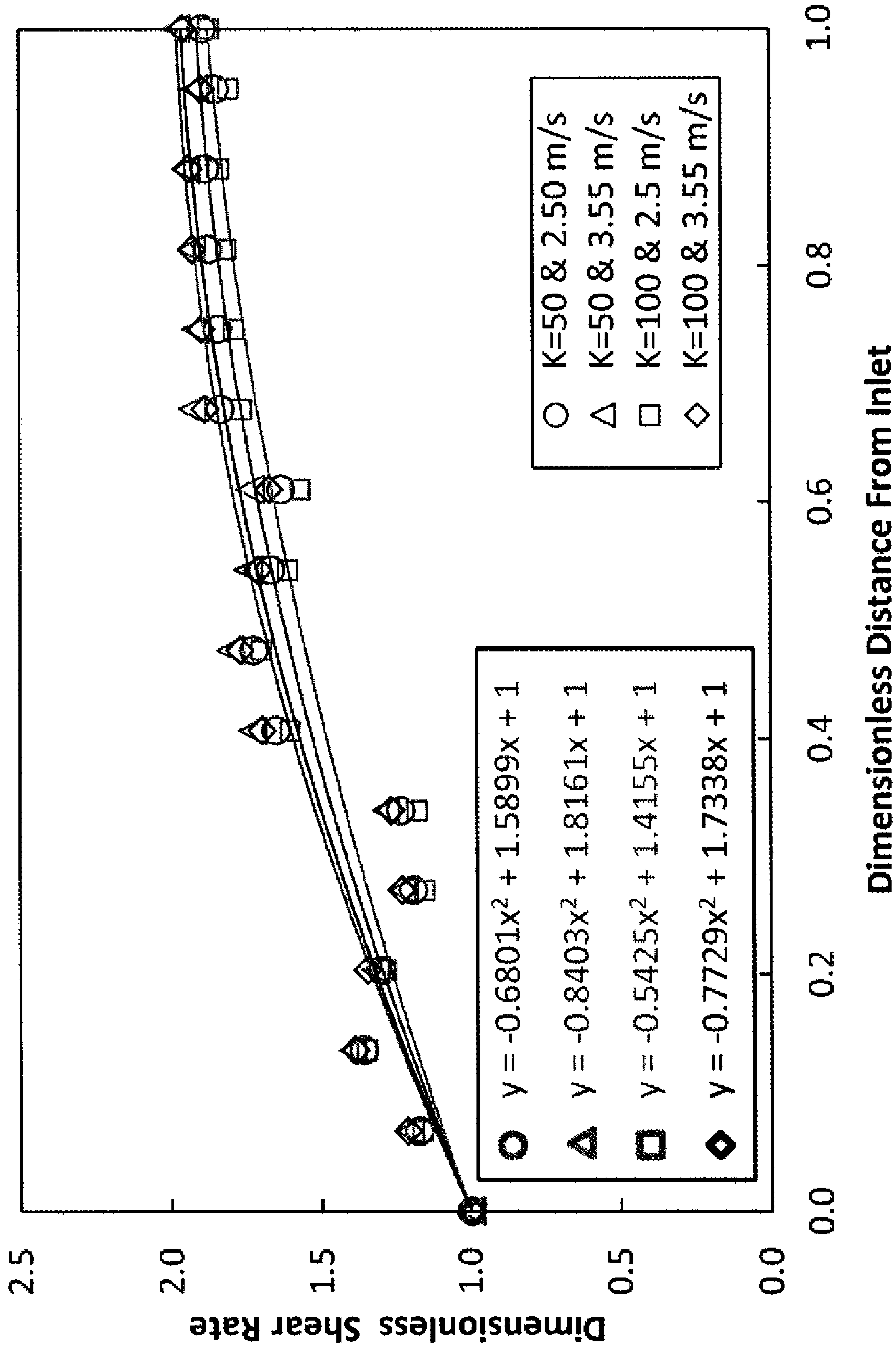

Dimensionless Shear Rate
2.5
2.0
1.5
1.0
0.5
0.0
0.0
0.2
0.4
0.6
0.8
1.0
Dimensionless Distance From Inlet
y = -0.6801x² + 1.5899x + 1
y = -0.8403x² + 1.8161x + 1
y = -0.5425x² + 1.4155x + 1
y = -0.7729x² + 1.7338x + 1
K=50 & 2.50 m/s
K=50 & 3.55 m/s
K=100 & 2.5 m/s
K=100 & 3.55 m/s

FIG. 36

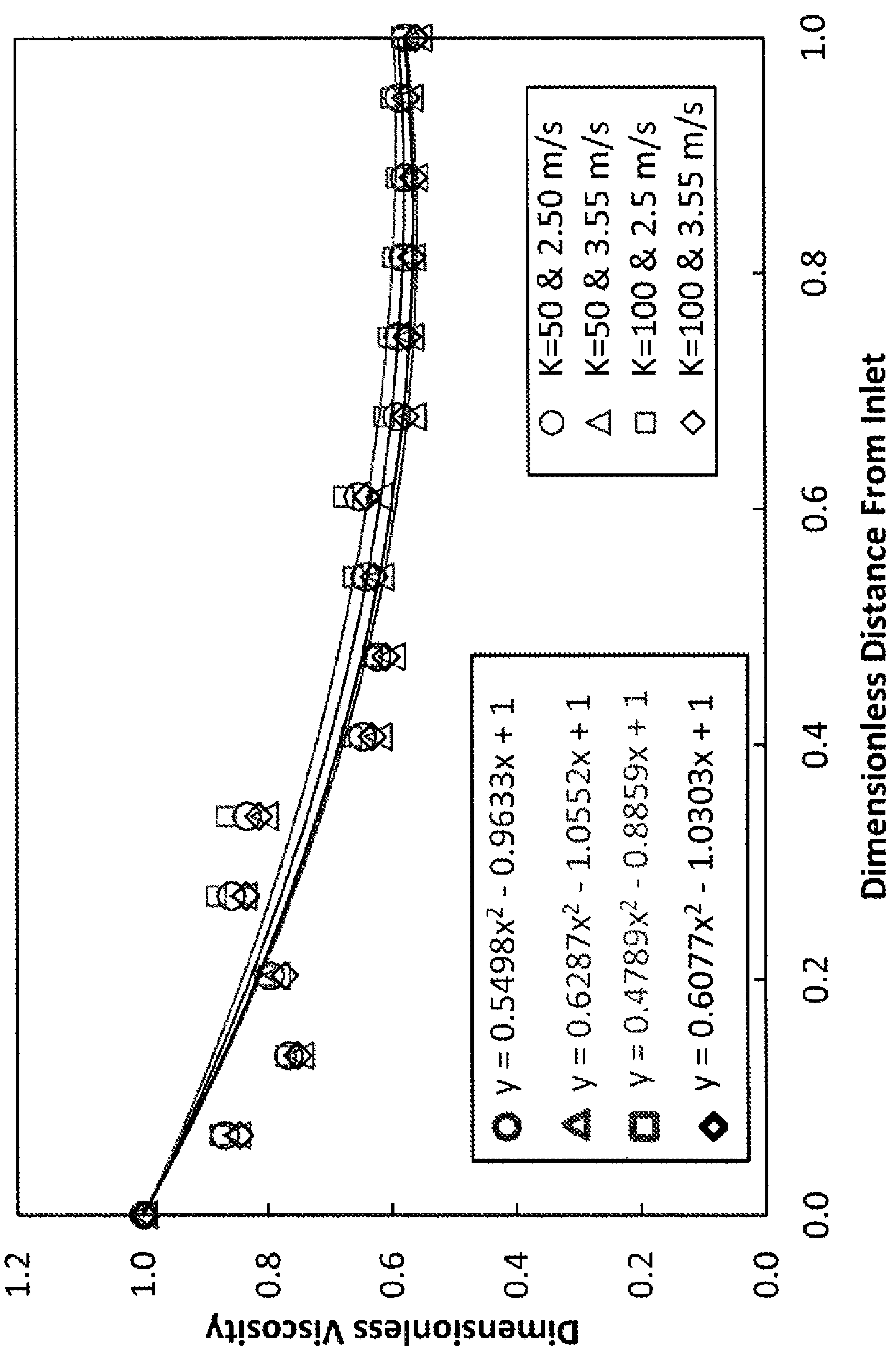

Dimensionless Viscosity
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0.0
0.2
0.4
0.6
0.8
1.0
Dimensionless Distance From Inlet
y = 0.5498x² - 0.9633x + 1
y = 0.6287x² - 1.0552x + 1
y = 0.4789x² - 0.8859x + 1
y = 0.6077x² - 1.0303x + 1
K=50 & 2.50 m/s
K=50 & 3.55 m/s
K=100 & 2.5 m/s
K=100 & 3.55 m/s

FIG. 37

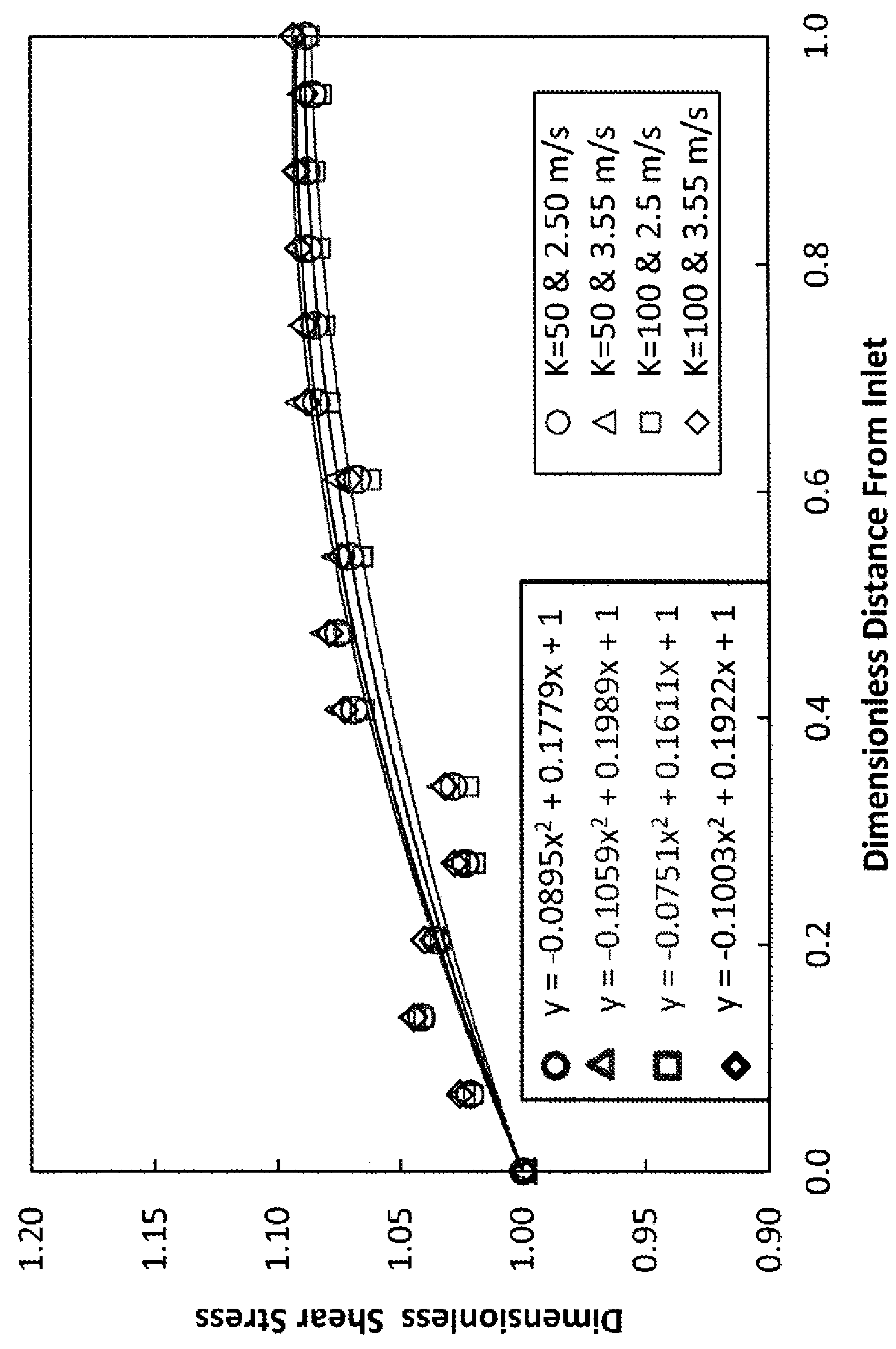
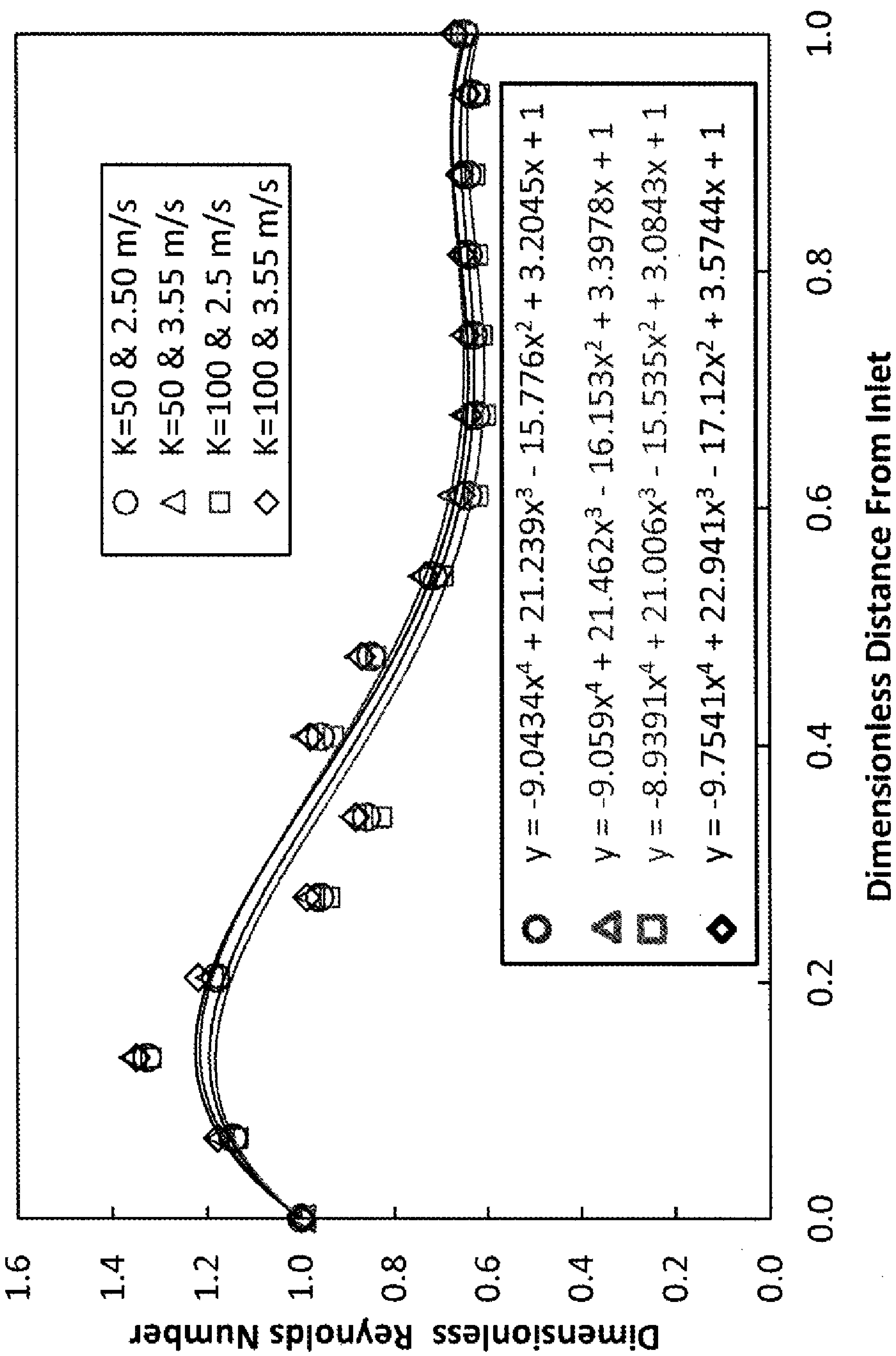

Dimensionless Shear Stress
1.20
1.15
1.10
1.05
1.00
0.95
0.90
0.0
0.2
0.4
0.6
0.8
1.0
Dimensionless Distance From Inlet
y = -0.0895x² + 0.1779x + 1
y = -0.1059x² + 0.1989x + 1
y = -0.0751x² + 0.1611x + 1
y = -0.1003x² + 0.1922x + 1
K=50 & 2.50 m/s
K=50 & 3.55 m/s
K=100 & 2.5 m/s
K=100 & 3.55 m/s

FIG. 38



K=50 & 2.50 m/s
K=50 & 3.55 m/s
K=100 & 2.5 m/s
K=100 & 3.55 m/s
y = -9.0434x4 + 21.239x3 - 15.776x2 + 3.2045x + 1
y = -9.059x4 + 21.462x3 - 16.153x2 + 3.3978x + 1
y = -8.9391x4 + 21.006x3 - 15.535x2 + 3.0843x + 1
y = -9.7541x4 + 22.941x3 - 17.12x2 + 3.5744x + 1
Dimensionless Reynolds Number
Dimensionless Distance From Inlet
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6

FIG. 39

MULTI-PIECE MOLD AND METHOD OF MAKING SLURRY DISTRIBUTOR

CROSS-REFERENCE TO RELATED APPLICATIONS

This patent application claims the benefit of priority to U.S. Provisional Patent Application No. 61/550,827, filed Oct. 24, 2011, and entitled, "Slurry Distributor, System, Method for Using, and Method for Making Same," which is incorporated in its entirety herein by this reference.

BACKGROUND

The present disclosure relates to continuous board (e.g., wallboard) manufacturing processes and, more particularly, to a mold and a method for making a slurry distributor for the distribution of an aqueous cementitious slurry, such as aqueous calcined gypsum slurry, for example.

It is well-known to produce gypsum board by uniformly dispersing calcined gypsum (commonly referred to as "stucco") in water to form an aqueous calcined gypsum slurry. The aqueous calcined gypsum slurry is typically produced in a continuous manner by inserting stucco and water and other additives into a mixer which contains means for agitating the contents to form a uniform gypsum slurry. The slurry is continuously directed toward and through a discharge outlet of the mixer and into a discharge conduit connected to the discharge outlet of the mixer. An aqueous foam can be combined with the aqueous calcined gypsum slurry in the mixer and/or in the discharge conduit. The stream of slurry passes through the discharge conduit from which it is continuously deposited onto a moving web of cover sheet material supported by a forming table. The slurry is allowed to spread over the advancing web. A second web of cover sheet material is applied to cover the slurry and form a sandwich structure of a continuous wallboard preform, which is subjected to forming, such as at a conventional forming station, to obtain a desired thickness. The calcined gypsum reacts with the water in the wallboard preform and sets as the wallboard preform moves down a manufacturing line. The wallboard preform is cut into segments at a point along the line where the wallboard preform has set sufficiently, the segments are flipped over, dried (e.g., in a kiln) to drive off excess water, and processed to provide the final wallboard product of desired dimensions.

Prior devices and methods for addressing some of the operational problems associated with the production of gypsum wallboard are disclosed in commonly-assigned U.S. Pat. Nos. 5,683,635; 5,643,510; 6,494,609; 6,874,930; 7,007,914; and 7,296,919, which are incorporated herein by reference.

The weight proportion of water relative to stucco that is combined to form a given amount of finished product is often referred to in the art as the "water-stucco ratio" (WSR). A reduction in the WSR without a formulation change will correspondingly increase the slurry viscosity, thereby reducing the ability of the slurry to spread on the forming table. Reducing water usage (i.e., lowering the WSR) in the gypsum board manufacturing process can yield many advantages, including the opportunity to reduce the energy demand in the process. However, spreading increasingly viscous gypsum slurries uniformly on the forming table remains a great challenge.

Furthermore, in some situations where the slurry is a multi-phase slurry including air, air-liquid slurry separation can develop in the slurry discharge conduit from the mixer.

As WSR decreases, the air volume increases to maintain the same dry density. The degree of air phase separated from the liquid slurry phase increases, thereby resulting in the propensity for larger mass or density variation.

It will be appreciated that this background description has been created by the inventors to aid the reader and is not to be taken as an indication that any of the indicated problems were themselves appreciated in the art. While the described principles can, in some aspects and embodiments, alleviate the problems inherent in other systems, it will be appreciated that the scope of the protected innovation is defined by the attached claims and not by the ability of any disclosed feature to solve any specific problem noted herein.

SUMMARY

In one aspect, the present disclosure is directed to embodiments of a mold for use in a method for making a slurry distributor according to principles of the present disclosure. In one embodiment, a multi-piece mold includes a plurality of mold segments adapted to be removably secured together. Each mold segment includes an exterior surface configured to define at least a portion of an interior surface of a slurry distributor. The mold segments are configured such that, when the mold segments are assembled together, the assembled mold segments define a substantially continuous exterior surface adapted to be a negative image of an interior flow region of a slurry distributor molded thereupon. Each mold segment has a maximum cross-sectional area in a plane substantially transverse to a direction of movement of the mold segment along a removal path out of a respective opening of the molded slurry distributor. The maximum cross-sectional area of each mold segment is up to about 150% of the smallest area of the interior flow region of the molded slurry distributor through which the mold segment traverses when moving along the respective removal path.

In another aspect of the present disclosure, embodiments of a method of making a slurry distributor are described. A plurality of mold segments of a multi-piece mold is assembled to define an exterior surface of the multi-piece mold. The assembled multi-piece mold is dipped into a solution of flexible material such that at least a portion of the multi-piece mold is submersed in the solution. The multi-piece mold is removed from the solution such that a layer of solution adheres substantially around the exterior surface of the multi-piece mold. The solution is allowed to cure such that an at least partially-solidified molded slurry distributor is formed around the multi-piece mold. The molded slurry distributor has an interior surface defining an interior flow region. The interior surface of the molded slurry distributor is in contacting relationship with the exterior surface of the multi-piece mold. The molded slurry distributor defines at least two openings each in fluid communication with the interior flow region.

The multi-piece mold is disassembled by removing each mold segment from the interior flow region of the slurry distributor through one of the openings of the molded slurry distributor such that each mold segment travels along a respective removal path from its assembled position in the assembled multi-piece mold out through the respective opening. Each mold segment has a maximum cross-sectional area in a plane substantially transverse to the direction of movement of the mold segment along the removal path out of the respective opening of the molded slurry distributor. The maximum cross-sectional area of each mold segment is up to about 150% of the smallest area of the interior

flow region of the molded slurry distributor through which the mold segment traverses when moving along the respective removal path.

In another aspect of the present disclosure, a slurry distributor made following a method using an embodiment of a multi-piece mold according to principles of the present disclosure can include a feed conduit and a distribution conduit in fluid communication therewith. The feed conduit can include a first feed inlet in fluid communication with the distribution conduit and a second feed inlet disposed in spaced relationship with the first feed inlet and in fluid communication with the distribution conduit. The distribution conduit can extend generally along a longitudinal axis and include an entry portion and a distribution outlet in fluid communication therewith. The entry portion is in fluid communication with the first and second feed inlets of the feed conduit. The distribution outlet extends a predetermined distance along a transverse axis, which is substantially perpendicular to the longitudinal axis.

In another aspect of the present disclosure, a slurry distributor made using an embodiment of a multi-piece mold according to principles of the present disclosure can be placed in fluid communication with a gypsum slurry mixer adapted to agitate water and calcined gypsum to form an aqueous calcined gypsum slurry. In still another aspect of the present disclosure, a slurry distributor made using an embodiment of a multi-piece mold according to principles of the present disclosure can be used in a method of preparing a gypsum product. For example, a slurry distributor can be used to distribute an aqueous calcined gypsum slurry upon an advancing web.

Further and alternative aspects and features of the disclosed principles will be appreciated from the following detailed description and the accompanying drawings. As will be appreciated, the slurry distribution systems disclosed herein are capable of being carried out and used in other and different embodiments, and capable of being modified in various respects. Accordingly, it is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory only and do not restrict the scope of the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view of an embodiment of a slurry distributor constructed in accordance with principles of the present disclosure.

FIG. **2** is a perspective view of the slurry distributor of FIG. **1** and a perspective view of an embodiment of a slurry distributor support constructed in accordance with principles of the present disclosure.

FIG. **3** is a front elevational view of the slurry distributor of FIG. **1** and the slurry distributor support of FIG. **2**.

FIG. **4** is a perspective view of an embodiment of a slurry distributor constructed in accordance with principles of the present disclosure that defines an interior geometry that is similar to the slurry distributor of FIG. **1**, but that is constructed from a rigid material and has a two-piece construction.

FIG. **5** is another perspective view of the slurry distributor of FIG. **4** but with a profiling system removed for illustrative purposes.

FIG. **6** is an isometric view of another embodiment of a slurry distributor constructed in accordance with principles of the present disclosure, which includes a first feed inlet and a second feed inlet disposed at about a sixty degree feed angle with respect to a longitudinal axis or machine direction of the slurry distributor.

FIG. **7** is a top plan view of the slurry distributor of FIG. **6**.

FIG. **8** is a rear elevational view of the slurry distributor of FIG. **6**.

FIG. **9** is a top plan view of a first piece of the slurry distributor of FIG. **6**, which has a two-piece construction.

FIG. **10** is a front perspective view of the slurry distributor piece of FIG. **9**.

FIG. **11** is an exploded view of the slurry distributor of FIG. **6** and a support system for the slurry distributor constructed in accordance with principles of the present disclosure.

FIG. **12** is a perspective view of the slurry distributor and the support system of FIG. **11**.

FIG. **13** is an exploded view of the slurry distributor of FIG. **6** and another embodiment of a support system constructed in accordance with principles of the present disclosure.

FIG. **14** is a perspective view of the slurry distributor and the support system of FIG. **13**.

FIG. **15** is a perspective view of an embodiment of a slurry distributor constructed in accordance with principles of the present disclosure that defines an interior geometry that is similar to the slurry distributor of FIG. **6**, but that is constructed from a flexible material and has an integral construction.

FIG. **16** is a top plan view of the slurry distributor of FIG. **15**.

FIG. **17** is an enlarged, perspective view of the interior geometry defined by the slurry distributor of FIG. **15**, illustrating progressive cross-sectional flow areas of a portion of the feed conduit thereof.

FIG. **18** is an enlarged, perspective view of the interior geometry of the slurry distributor of FIG. **15**, illustrating another progressive cross-sectional flow area of the feed conduit.

FIG. **19** is an enlarged, perspective view of the interior geometry of the slurry distributor of FIG. **15**, illustrating yet another progressive cross-sectional flow area of the feed conduit which is aligned with a half of an entry portion to a distribution conduit of the slurry distributor of FIG. **15**.

FIG. **20** is a perspective view of the slurry distributor of FIG. **15** and another embodiment of a support system constructed in accordance with principles of the present disclosure.

FIG. **21** is a perspective view as in FIG. **20**, but with a support frame removed for illustrative purposes to show a plurality of retaining plates in distributed relationship with the slurry distributor of FIG. **15**.

FIG. **22** is a perspective view of an embodiment of a multi-piece mold for making a slurry distributor as in FIG. **1** constructed in accordance with principles of the present disclosure.

FIGS. **22**A-K are various detail views of mold segments of the multi-piece mold of FIG. **22**.

FIG. **23** is a top plan view of the mold of FIG. **22**.

FIG. **24** is an exploded view of an embodiment of a multi-piece mold for making a slurry distributor as in FIG. **15** constructed in accordance with principles of the present disclosure.

FIG. **25** is a perspective view of another embodiment of a mold for making a piece of a two-piece slurry distributor constructed in accordance with principles of the present disclosure.

FIG. **26** is a top plan view of the mold of FIG. **25**.

FIG. **27** is a schematic plan diagram of an embodiment of a gypsum slurry mixing and dispensing assembly including a slurry distributor in accordance with principles of the present disclosure.

FIG. **28** is a schematic plan diagram of another embodiment of a gypsum slurry mixing and dispensing assembly including a slurry distributor in accordance with principles of the present disclosure.

FIG. **29** is a schematic elevational diagram of an embodiment of a wet end of a gypsum wallboard manufacturing line in accordance with principles of the present disclosure.

FIG. **30** is a perspective view of an embodiment of a flow splitter constructed in accordance with principles of the present disclosure suitable for use in a gypsum slurry mixing and dispensing assembly including a slurry distributor.

FIG. **31** is a side elevational view, in section, of the flow splitter of FIG. **30**.

FIG. **32** is a side elevational view of the flow splitter of FIG. **30** with an embodiment of a squeezing apparatus constructed in accordance with principles of the present disclosure mounted thereto.

FIG. **33** is a top plan view of a half portion of a slurry distributor similar to the slurry distributor of FIG. **15**.

FIG. **34** is a plot of the data from Table I of Example 1 showing the dimensionless distance from the feed inlet versus the dimensionless area and the dimensionless hydraulic radius of the half portion of the slurry distributor of FIG. **33**.

FIG. **35** is a plot of the data from Tables II and III of Examples 2 and 3, respectively, showing the dimensionless distance from the feed inlet versus the dimensionless velocity of a flow of modeled slurry moving through the half portion of the slurry distributor of FIG. **33**.

FIG. **36** is a plot of the data from Tables II and III of Examples 2 and 3, respectively, showing the dimensionless distance from the feed inlet versus the dimensionless shear rate in the modeled slurry moving through the half portion of the slurry distributor of FIG. **33**.

FIG. **37** is a plot of the data from Tables II and III of Examples 2 and 3, respectively, showing the dimensionless distance from the feed inlet versus the dimensionless viscosity of the modeled slurry moving through the half portion of the slurry distributor of FIG. **33**.

FIG. **38** is a plot of the data from Tables II and III of Examples 2 and 3, respectively, showing the dimensionless distance from the feed inlet versus the dimensionless shear stress in the modeled slurry moving through the half portion of the slurry distributor of FIG. **33**.

FIG. **39** is a plot of the data from Tables II and III of Examples 2 and 3, respectively, showing the dimensionless distance from the feed inlet versus the dimensionless Reynolds number of the modeled slurry moving through the half portion of the slurry distributor of FIG. **33**.

DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

The present disclosure provides various embodiments of a slurry distribution system that can be used in the manufacture of products, including cementitious products such as gypsum wallboard, for example. Embodiments of a slurry distributor constructed in accordance with principles of the present disclosure can be used in a manufacturing process to effectively distribute a multi-phase slurry, such as one containing air and liquid phases, such as found in an aqueous foamed gypsum slurry, for example. Embodiments of a method of making a slurry distributor according to principles of the present disclosure can use a multi-piece mold in a dip molding process.

Embodiments of a distribution system constructed in accordance with principles of the present disclosure can be used to distribute a slurry (e.g., an aqueous calcined gypsum slurry) onto an advancing web (e.g., paper or mat) moving on a conveyor during a continuous board (e.g., wallboard) manufacturing process. In one aspect, a slurry distribution system constructed in accordance with principles of the present disclosure can be used in a conventional gypsum drywall manufacturing process as, or part of, a discharge conduit attached to a mixer adapted to agitate calcined gypsum and water to form an aqueous calcined gypsum slurry.

Embodiments of a slurry distribution system constructed in accordance with principles of the present disclosure are aimed at accomplishing wider distribution (along the cross-machine direction) of a uniform gypsum slurry. Embodiments of a slurry distribution system of the present disclosure are suitable for use with a gypsum slurry having a range of WSRs, including WSRs conventionally used to manufacture gypsum wallboard and those that are relatively lower and have a relatively higher viscosity. Furthermore, a gypsum slurry distribution system of the present disclosure can be used to help control air-liquid phase separation, such as, in aqueous foamed gypsum slurry, including foamed gypsum slurry having a very high foam volume. The spreading of the aqueous calcined gypsum slurry over the advancing web can be controlled by routing and distributing the slurry using a distribution system as shown and described herein.

Embodiments of a method of preparing a gypsum product in accordance with principles of the present disclosure can include distributing an aqueous calcined gypsum slurry upon an advancing web using a slurry distributor constructed in accordance with principles of the present disclosure. Various embodiments of a method of distributing an aqueous calcined gypsum slurry upon a moving web are described herein.

Turning now to the Figures, there is shown in FIGS. **1-3** an embodiment of a slurry distributor **120** according to principles of the present disclosure, and in FIGS. **4** and **5**, another embodiment of a slurry distributor **220** according to principles of the present disclosure is shown. The slurry distributor **120** shown in FIGS. **1-3** is constructed from a resiliently flexible material, whereas the slurry distributor **220** shown in FIGS. **3** and **4** is made from a relatively rigid material. However, the interior flow geometry of both slurry distributors **120**, **220** in FIGS. **1-5** is the same, and reference should also be made to FIG. **5** when considering the slurry distributor **120** of FIGS. **1-3**.

Referring to FIG. **1**, the slurry distributor **120** includes a feed conduit **122**, which has first and second feed inlets **124**, **125**, and a distribution conduit **128**, which includes a distribution outlet **130** and is in fluid communication with the feed conduit **128**. A profiling system **132** (see FIG. **3**) adapted to locally vary the size of the distribution outlet **130** of the distribution conduit **128** can also be provided.

Referring to FIG. **1**, the feed conduit **122** extends generally along a transverse axis or cross-machine direction **60**, which is substantially perpendicular to a longitudinal axis or machine direction **50**. The first feed inlet **124** is in spaced relationship with the second feed inlet **125**. The first feed inlet **124** and the second feed inlet **125** define respective openings **134**, **135** that have substantially the same area. The illustrated openings **134**, **135** of the first and second feed inlets **124**, **125** both have a circular cross-sectional shape as illustrated in this example. In other embodiments, the cross-sectional shape of the feed inlets **124**, **125** can take other forms, depending upon the intended applications and process conditions present.

The first and second feed inlets **124**, **125** are in opposing relationship to each other along the cross-machine axis **60** such that the first and second feed inlets **124**, **125** are disposed at substantially a 90° angle to the machine axis **50**. In other embodiments the first and second feed inlets **124**, **125** can be oriented in a different manner with respect to the machine direction. For example, in some embodiments, the first and second feed inlets **124**, **125** can be at an angle between 0° and about 135° with respect to the machine direction **50**.

The feed conduit **122** includes first and second entry segments **136**, **137** and a bifurcated connector segment **139** disposed between the first and second entry segments **136**, **137**. The first and second entry segments **136**, **137** are generally cylindrical and extend along the transverse axis **60** such that they are substantially parallel to a plane **57** defined by the longitudinal axis **50** and the transverse axis **60**. The first and second feed inlets **124**, **125** are disposed at the distal ends of the first and the second entry segments **136**, **137**, respectively, and are in fluid communication therewith.

In other embodiments the first and second feed inlets **124**, **125** and the first and second entry segments **136**, **137** can be oriented in a different manner with respect to the transverse axis **60**, the machine direction **50**, and/or the plane **57** defined by the longitudinal axis **50** and the transverse axis **60**. For example, in some embodiments, the first and second feed inlets **124**, **125** and the first and second entry segments **136**, **137** can each be disposed substantially in the plane **57** defined by the longitudinal axis **50** and the transverse axis **60** at a feed angle θ with respect to the longitudinal axis or machine direction **50** which is an angle in a range up to about 135° with respect to the machine direction **50**, and in other embodiments in a range from about 30° to about 135°, and in yet other embodiments in a range from about 45° to about 135°, and in still other embodiments in a range from about 40° to about 110°.

The bifurcated connector segment **139** is in fluid communication with the first and second feed inlets **124**, **125** and the first and the second entry segments **136**, **137**. The bifurcated connector segment **139** includes first and second shaped ducts **141**, **143**. The first and second feed inlets **124**, **125** of the feed conduit **22** are in fluid communication with the first and second shaped ducts **141**, **143**, respectively. The first and second shaped ducts **141**, **143** of the connector segment **139** are adapted to receive a first flow in a first feed direction **190** and a second flow in a second flow direction **191** of aqueous calcined gypsum slurry from the first and second feed inlets **124**, **125**, respectively, and to direct the first and second flows **190**, **191** of aqueous calcined gypsum slurry into the distribution conduit **128**.

As shown in FIG. **5**, the first and second shaped ducts **141**, **143** of the connector segment **139** define first and second feed outlets **140**, **145** respectively in fluid communication with the first and second feed inlets **124**, **125**. Each feed outlet **140**, **145** is in fluid communication with the distribution conduit **128**. Each of the illustrated first and second feed outlets **140**, **145** defines an opening **142** with a generally rectangular inner portion **147** and a substantially circular side portion **149**. The circular side portions **145** are disposed adjacent side walls **151**, **153** of the distribution conduit **128**.

In embodiments, the openings **142** of the first and second feed outlets **140**, **145** can have a cross-sectional area that is larger than the cross-sectional area of the openings **134**, **135** of the first feed inlet **124** and the second feed inlet **125**, respectively. For example, in some embodiments, the cross-sectional area of the openings **142** of the first and second feed outlets **140**, **145** can be in a range from greater than to about 300% greater than the cross-sectional area of the openings **134**, **135** of the first feed inlet **124** and the second feed inlet **125**, respectively, in a range from greater than to about 200% greater in other embodiments, and in a range from greater than to about 150% greater in still other embodiments.

In embodiments, the openings **142** of the first and second feed outlets **140**, **145** can have a hydraulic diameter (4× cross-sectional area/perimeter) that is smaller than the hydraulic diameter of the openings **134**, **135** of the first feed inlet **124** and the second feed inlet **125**, respectively. For example, in some embodiments, the hydraulic diameter of the openings **142** of the first and second feed outlets **140**, **145** can be about 80% or less than the hydraulic diameter of the openings **134**, **135** of the first feed inlet **124** and the second feed inlet **125**, respectively, about 70% or less in other embodiments, and about 50% or less in still other embodiments

Referring back to FIG. **1**, the connector segment **139** is substantially parallel to the plane **57** defined by the longitudinal axis **50** and the transverse axis **60**. In other embodiments the connector segment **139** can be oriented in a different manner with respect to the transverse axis **60**, the machine direction **50**, and/or the plane **57** defined by the longitudinal axis **50** and the transverse axis **60**.

The first feed inlet **124**, the first entry segment **136**, and the first shaped duct **141** are a mirror image of the second feed inlet **125**, the second entry segment **137**, and the second shaped duct **143**, respectively. Accordingly, it will be understood that the description of one feed inlet is applicable to the other feed inlet, the description of one entry segment is applicable to the other entry segment, and the description of one shaped duct is applicable to the other shaped duct, as well in a corresponding manner.

The first shaped duct **141** is fluidly connected to the first feed inlet **124** and the first entry segment **136**. The first shaped duct **141** is also fluidly connected to the distribution conduit **128** to thereby help fluidly connect the first feed inlet **124** and the distribution outlet **130** such that the first flow **190** of slurry can enter the first feed inlet **124**; travel through the first entry segment **136**, the first shaped duct **141**, and the distribution conduit **128**; and be discharged from the slurry distributor **120** through the distribution outlet **130**.

The first shaped duct **141** has a front, outer curved wall **157** and an opposing rear, inner curved wall **158** defining a curved guide surface **165** adapted to redirect the first flow of slurry from the first feed flow direction **190**, which is substantially parallel to the transverse or cross-machine direction **60**, to an outlet flow direction **192**, which is substantially parallel to the longitudinal axis or machine direction **50** and substantially perpendicular to the first feed flow direction **190**. The first shaped duct **141** is adapted to receive the first flow of slurry moving in the first feed flow direction **190** and redirect the slurry flow direction by a change in direction angle α, as shown in FIG. **9**, such that the first flow of slurry is conveyed into the distribution conduit **128** moving substantially in the outlet flow direction **192**.

In use, the first flow of aqueous calcined gypsum slurry passes through the first feed inlet **124** in the first feed direction **190**, and the second flow of aqueous calcined gypsum slurry passes through the second feed inlet **125** in the second feed direction **191**. The first and second feed directions **190**, **191** can be symmetrical with respect to each other along the longitudinal axis **50** in some embodiments. The first flow of slurry moving in the first feed flow direction **190** is redirected in the slurry distributor **120** through a change in direction angle α in a range up to about 135° to the outlet flow direction **192**. The second flow of slurry moving in the second feed flow direction **191** is redirected in the slurry distributor **120** through a change in direction angle α in a range up to about 135° to the outlet flow direction **192**. The combined first and second flows **190**, **191** of aqueous calcined gypsum slurry discharge from the slurry distributor **120** moving generally in the outlet flow direction **192**. The outlet flow direction **192** can be substantially parallel to the longitudinal axis or machine direction **50**.

For example, in the illustrated embodiment, the first flow of slurry is redirected from the first feed flow direction **190** along the cross-machine direction **60** through a change in direction angle α of about ninety degrees about the vertical axis **55** to the outlet flow direction **192** along the machine direction **50**. In some embodiments, the flow of slurry can be redirected from a first feed flow direction **190** through a change in direction angle α about the vertical axis **55** which is in a range up to about 135° to the outlet flow direction **192**, and in other embodiments in a range from about 30° to about 135°, and in yet other embodiments in a range from about 45° to about 135°, and in still other embodiments in a range from about 40° to about 110°.

In some embodiments, the shape of the rear curved guide surface **165** can be generally parabolic, which in the illustrated embodiment can be defined by a parabola of the form Ax^2+B. In alternate embodiments, higher order curves may be used to define the rear curved guide surface **165** or, alternatively, the rear, inner wall **158** can have a generally curved shape that is made up of straight or linear segments that have been oriented at their ends to collectively define a generally curved wall. Moreover, the parameters used to define the specific shape factors of the outer wall can depend on specific operating parameters of the process in which the slurry distributor will be used.

At least one of the feed conduit **122** and the distribution conduit **128** can include an area of expansion having a cross-sectional flow area that is greater than a cross-sectional flow area of an adjacent area upstream from the area of expansion in a direction from the feed conduit **122** toward the distribution conduit **128**. The first entry segment **136** and/or the first shaped duct **141** can have a cross section that varies along the direction of flow to help distribute the first flow of slurry moving therethrough. The shaped duct **141** can have a cross sectional flow area that increases in a first flow direction **195** from the first feed inlet **124** toward the distribution conduit **128** such that the first flow of slurry is decelerated as it passes through the first shaped duct **141**. In some embodiments, the first shaped duct **141** can have a maximum cross-section flow area at a predetermined point along the first flow direction **195** and decrease from the maximum cross-sectional flow area at points further along the first flow direction **195**.

In some embodiments, the maximum cross-sectional flow area of the first shaped duct **141** is about 200% of the cross-sectional area of the opening **134** of the first feed inlet **124** or less. In yet other embodiments, the maximum cross-sectional flow area of the shaped duct **141** is about 150% of the cross-sectional area of the opening **134** of the first feed inlet **124** or less. In still other embodiments, the maximum cross-sectional flow area of the shaped duct **141** is about 125% of the cross-sectional area of the opening **134** of the first feed inlet **124** or less. In yet other embodiments, the maximum cross-sectional flow area of the shaped duct **141** is about 110% of the cross-sectional area of the opening **134** of the first feed inlet **124** or less. In some embodiments, the cross-sectional flow area is controlled such that the flow area does not vary more than a predetermined amount over a given length to help prevent large variations in the flow regime.

In some embodiments, the first entry segment **136** and/or the first shaped duct **141** can include one or more guide channels **167**, **168** that are adapted to help distribute the first flow of slurry toward the outer and/or the inner walls **157**, **158** of the feed conduit **122**. The guide channels **167**, **168** are adapted to increase the flow of slurry around the boundary wall layers of the slurry distributor **120**.

Referring to FIGS. **1** and **5**, the guide channels **167**, **168** can be configured to have a larger cross-sectional area than an adjacent portion **171** of the feed conduit **122** which defines a restriction that promotes flow to the adjacent guide channel **167**, **168** respectively disposed at the wall region of the slurry distributor **120**. In the illustrated embodiment, the feed conduit **122** includes the outer guide channel **167** adjacent the outer wall **157** and the sidewall **151** of the distribution conduit **128** and the inner guide channel **168** adjacent the inner wall **158** of the first shaped duct **141**. The cross-sectional areas of the outer and inner guide channels **167**, **168** can become progressively smaller moving in the first flow direction **195**. The outer guide channel **167** can extend substantially along the sidewall **151** of the distribution conduit **128** to the distribution outlet **130**. At a given cross-sectional location through the first shaped duct **141** in a direction perpendicular to the first flow direction **195**, the outer guide channel **167** has a larger cross-sectional area than the inner guide channel **168** to help divert the first flow of slurry from its initial line of movement in the first feed direction **190** toward the outer wall **157**.

Providing guide channels adjacent wall regions can help direct or guide slurry flow to those regions, which can be areas in conventional systems where “dead spots” of low slurry flow are found. By encouraging slurry flow at the wall regions of the slurry distributor **120** through the provision of guide channels, slurry buildup inside the slurry distributor is discouraged and the cleanliness of the interior of the slurry distributor **120** can be enhanced. The frequency of slurry buildup breaking off into lumps which can tear the moving web of cover sheet material can also be decreased.

In other embodiments, the relative sizes of the outer and inner guide channels **167**, **168** can be varied to help adjust the slurry flow to improve flow stability and reduce the occurrence of air-liquid slurry phase separation. For example, in applications using a slurry that is relatively more viscous, at a given cross-sectional location through the first shaped duct **141** in a direction perpendicular to the first flow direction **195**, the outer guide channel **167** can have a smaller cross-sectional area than the inner guide channel **168** to help urge the first flow of slurry toward the inner wall **158**.

The inner curved walls **158** of the first and second shaped ducts **141**, **142** meet to define a peak **175** adjacent an entry portion **152** of the distribution conduit **128**. The peak **175** effectively bifurcates the connector segment **139**. Each feed outlet **140**, **145** is in fluid communication with the entry portion **152** of the distribution conduit **128**.

The location of the peak **175** along the longitudinal axis **50** can vary in other embodiments. For example, the inner curved walls **158** of the first and second shaped ducts **141**, **142** can be less curved in other embodiments such that the peak **175** is further away from the distribution outlet **130** along the longitudinal axis **50** than as shown in the illustrated slurry distributor **120**. In other embodiments, the peak **175** can be closer to the distribution outlet **130** along the longitudinal axis **50** than as shown in the illustrated slurry distributor **120**.

The distribution conduit **128** is substantially parallel to the plane **57** defined by the longitudinal axis **50** and the transverse axis **60** and is adapted to urge the combined first and second flows of aqueous calcined gypsum slurry from the first and second shaped ducts **141**, **142** into a generally two-dimensional flow pattern for enhanced stability and uniformity. The distribution outlet **130** has a width that extends a predetermined distance along the transverse axis **60** and a height that extends along a vertical axis **55**, which is mutually perpendicular to the longitudinal axis **50** and the transverse axis **60**. The height of the distribution outlet **130** is small relative to its width. The distribution conduit **128** can be oriented relative to a moving web of cover sheet upon a forming table such that the distribution conduit **128** is substantially parallel to the moving web.

The distribution conduit **128** extends generally along the longitudinal axis **50** and includes the entry portion **152** and the distribution outlet **130**. The entry portion **152** is in fluid communication with the first and second feed inlets **124**, **125** of the feed conduit **122**. Referring to FIG. **5**, the entry portion **152** is adapted to receive both the first and the second flows of aqueous calcined gypsum slurry from the first and second feed inlets **124**, **125** of the feed conduit **122**. The entry portion **152** of the distribution conduit **128** includes a distribution inlet **154** in fluid communication with the first and second feed outlets **140**, **145** of the feed conduit **122**. The illustrated distribution inlet **154** defines an opening **156** that substantially corresponds to the openings **142** of the first and second feed outlets **140**, **145**. The first and second flows of aqueous calcined gypsum slurry combine in the distribution conduit **128** such that the combined flows move generally in the outlet flow direction **192** which can be substantially aligned with the line of movement of a web of cover sheet material moving over a forming table in a wallboard manufacturing line.

The distribution outlet **130** is in fluid communication with the entry portion **152** and thus the first and second feed inlets **124**, **125** and the first and second feed outlets **140**, **145** of the feed conduit **122**. The distribution outlet **130** is in fluid communication with the first and second shaped ducts **141**, **143** and is adapted to discharge the combined first and second flows of slurry therefrom along the outlet flow direction **192** upon a web of cover sheet material advancing along the machine direction **50**.

Referring to FIG. **1**, the illustrated distribution outlet **130** defines a generally rectangular opening **181** with semi-circular narrow ends **183**, **185**. The semi-circular ends **183**, **185** of the opening **181** of the distribution outlet **130** can be the terminating end of the outer guide channels **167** disposed adjacent the side walls **151**, **153** of the distribution conduit **128**.

The opening **181** of the distribution outlet **130** has an area which is greater than the sum of the areas of the openings **134**, **135** of the first and second feed inlets **124**, **125** and is smaller than the area of the sum of the openings **142** of the first and second feed outlets **140**, **145** (i.e., the opening **156** of the distribution inlet **154**). Accordingly, the cross-sectional area of the opening **156** of the entry portion **152** of the distribution conduit **128** is greater than the cross-sectional area of the opening **181** of the distribution outlet **130**.

For example, in some embodiments, the cross-sectional area of the opening **181** of the distribution outlet **130** can be in a range from greater than to about 400% greater than the sum of the cross-sectional areas of the openings **134**, **135** of the first and second feed inlets **124**, **125**, in a range from greater than to about 200% greater in other embodiments, and in a range from greater than to about 150% greater in still other embodiments. In other embodiments, the ratio of the sum of the cross-sectional areas of the openings **134**, **135** of the first and second feed inlets **124**, **125** to the cross-sectional area of the opening **181** of the distribution outlet **130** can be varied based upon one or more factors, including the speed of the manufacturing line, the viscosity of the slurry being distributed by the distributor **120**, the width of the board product being made with the distributor **120**, etc. In some embodiments, the cross-sectional area of the opening **156** of the entry portion **152** of the distribution conduit **128** can be in a range from greater than to about 200% greater than the cross-sectional area of the opening **181** of the distribution outlet **130**, in a range from greater than to about 150% greater in other embodiments, and in a range from greater than to about 125% greater in still other embodiments.

The distribution outlet **130** extends substantially along the transverse axis **60**. The opening **181** of the distribution outlet **130** has a width W_1 of about twenty-four inches along the transverse axis **60** and a height H_1 of about one inch along the vertical axis **55** (see FIG. **3**, also). In other embodiments, the size and shape of the opening **181** of the distribution outlet **130** can be varied.

The distribution outlet **130** is disposed intermediately along the transverse axis **60** between the first feed inlet **124** and the second feed inlet **125** such that the first feed inlet **124** and the second feed inlet **125** are disposed substantially the same distance D_1, D_2 from a transverse central midpoint **187** of the distribution outlet **130** (see FIG. **3**, also). The distribution outlet **130** can be made from a resiliently flexible material such that its shape is adapted to be variable along the transverse axis **60**, such as by the profiling system **32**, for example.

It is contemplated that the width W_1 and/or height H_1 of the opening **181** of the distribution outlet **130** can be varied in other embodiments for different operating conditions. In general, the overall dimensions of the various embodiments for slurry distributors as disclosed herein can be scaled up or down depending on the type of product being manufactured (for example, the thickness and/or width of manufactured product), the speed of the manufacturing line being used, the rate of deposition of the slurry through the distributor, the viscosity of the slurry, and the like. For example, the width W_1, along the transverse axis **60**, of the distribution outlet **130** for use in a wallboard manufacturing process, which conventionally is provided in nominal widths no greater than fifty-four inches, can be within a range from about eight to about fifty-four inches in some embodiments, and in other embodiments within a range from about eighteen inches to about thirty inches. In other embodiments, the ratio of the width W_1, along the transverse axis **60**, of the distribution outlet **130** to the maximum nominal width of the panel being produced on the manufacturing system using the slurry distributor constructed according to principles of the present disclosure can be in a range from about 1/7 to about 1, in a range from about 1/3 to about 1 in other embodiments, in a range from about 1/3 to about 2/3 in yet other embodiments, and in a range from about 1/2 to about 1 in still other embodiments.

The height of the distribution outlet can be within a range from about 3/16 inch to about two inches in some embodiments, and in other embodiments between about 3/16 inch and about an inch. In some embodiments including a rectangular distribution outlet, the ratio of the rectangular width to the rectangular height of the outlet opening can be about 4 or more, in other embodiments about 8 or more, in some embodiments from about 4 to about 288, in other embodiments from about 9 to about 288, in other embodiments from about 18 to about 288, and in still other embodiments from about 18 to about 160.

The distribution conduit **128** includes a converging portion **182** in fluid communication with the entry portion **152**. The height of the converging portion **182** is less than the height at the maximum cross-sectional flow area of the first and second shaped ducts **141**, **143** and less than the height of the opening **181** of the distribution outlet **130**. In some embodiments, the height of the converging portion **182** can be about half the height of the opening **181** of the distribution outlet **130**.

The converging portion **182** and the height of the distribution outlet **130** can cooperate together to help control the average velocity of the combined first and second flows of aqueous calcined gypsum being distributed from the distribution conduit **128**. The height and/or width of the distribution outlet **130** can be varied to adjust the average velocity of the combined first and second flows of slurry discharging from the slurry distributor **120**.

In some embodiments, the outlet flow direction **192** is substantially parallel to the plane **57** defined by the machine direction **50** and the transverse cross-machine direction **60** of the system transporting the advancing web of cover sheet material. In other embodiments, the first and second feed directions **190**, **191** and the outlet flow direction **192** are all substantially parallel to the plane **57** defined by the machine direction **50** and the transverse cross-machine direction **60** of the system transporting the advancing web of cover sheet material. In some embodiments, the slurry distributor can be adapted and arranged with respect to the forming table such that the flow of slurry is redirected in the slurry distributor **120** from the first and second feed directions **190**, **191** to the outlet flow direction **192** without undergoing substantial flow redirection by rotating about the cross-machine direction **60**.

In some embodiments, the slurry distributor can be adapted and arranged with respect to the forming table such that the first and second flows of slurry are redirected in the slurry distributor from the first and second feed directions **190**, **191** to the outlet flow direction **192** by redirecting the first and second flows of slurry by rotating about the cross-machine direction **60** over an angle of about forty-five degrees or less. Such a rotation can be accomplished in some embodiments by adapting the slurry distributor such that the first and second feed inlets **124**, **125** and the first and second feed directions **190**, **191** of the first and second flows of slurry are disposed at a vertical offset angle ω with respect to the vertical axis **55** and the plane **57** formed by the machine axis **50** and the cross-machine axis **60**. In embodiments, the first and second feed inlets **124**, **125** and the first and second feed directions **190**, **191** of the first and second flows of slurry can be disposed at a vertical offset angle ω within a range from zero to about sixty degrees such that the flow of slurry is redirected about the machine axis **50** and moves along the vertical axis **55** in the slurry distributor **120** from the first and second feed directions **190**, **191** to the outlet flow direction **192**. In embodiments, at least one of the respective entry segment **136**, **137** and the shaped ducts **141**, **143** can be adapted to facilitate the redirection of the slurry about the machine axis **50** and along the vertical axis **55**. In embodiments, the first and second flows of slurry can be redirected from the first and second feed directions **190**, **191** through a change in direction angle α about an axis substantially perpendicular to vertical offset angle ω and/or one or more other rotational axes within a range of about forty-five degrees to about one hundred fifty degrees to the outlet flow direction **192** such that the outlet flow direction **192** is generally aligned with the machine direction **50**.

In use, first and second flows of aqueous calcined gypsum slurry pass through the first and second feed inlets **124**, **125** in converging first and second feed directions **190**, **191**. The first and second shaped ducts **141**, **143** redirect the first and second flows of slurry from the first feed direction **190** and the second feed direction **191** so that the first and second flows of slurry move over a change in direction angle α from both being substantially parallel to the transverse axis **60** to both being substantially parallel to the machine direction **50**. The distribution conduit **128** can be positioned such that it extends along the longitudinal axis **50** which substantially coincides with the machine direction **50** along which a web of cover sheet material moves in a method making a gypsum board. The first and second flows of aqueous calcined gypsum slurry combine in the slurry distributor **120** such that the combined first and second flows of aqueous calcined gypsum slurry pass through the distribution outlet **130** in the outlet flow direction **192** generally along the longitudinal axis **50** and in the direction of the machine direction.

Referring to FIG. **2**, a slurry distributor support **100** can be provided to help support the slurry distributor **120**, which in the illustrated embodiment is made from a flexible material, such as PVC or urethane, for example. The slurry distributor support **100** can be made from a suitable rigid material to help support the flexible slurry distributor **120**. The slurry distributor support **100** can include a two-piece construction. The two pieces **101**, **103** can be pivotally movable with respect to each other about a hinge **105** at the rear end thereof to allow for ready access to an interior **107** of the support **100**. The interior **107** of the support **100** can be configured such that the interior **107** substantially conforms to the exterior of the slurry distributor **120** to help limit the amount of movement the slurry distributor **120** can undergo with respect to the support **100** and/or to help define the interior geometry of the slurry distributor **120** through which a slurry will flow.

Referring to FIG. **3**, in some embodiments, the slurry distributor support **100** can be made from a suitable resiliently flexible material that provides support and is able to be deformed in response to the profiling system **132** mounted to the support **100**. The profiling system **132** can be mounted to the support **100** adjacent the distribution outlet **130** of the slurry distributor **120**. The profiling system **132** so installed can act to vary the size and/or shape of the distribution outlet **130** of the distribution conduit **128** by also varying the size and/or shape of the closely conforming support **100**, which in turn, influences the size and/or shape of the distribution outlet **130**.

Referring to FIG. **3**, the profiling system **132** can be adapted to selectively change the size and/or shape of the opening **181** of the distribution outlet **130**. In some embodiments, the profiling system can be used to selectively adjust the height H_1 of the opening **181** of the distribution outlet **130**.

The illustrated profiling system **132** includes a plate **90**, a plurality of mounting bolts **92** securing the plate to the distribution conduit **128**, and a series of adjustment bolts **94**, **95** threadingly secured thereto. The mounting bolts **92** are used to secure the plate **90** to the support **100** adjacent the distribution outlet **130** of the slurry distributor **120**. The plate **90** extends substantially along the transverse axis **60**. In the illustrated embodiment, the plate **90** is in the form of a length of angle iron. In other embodiments, the plate **90** can have different shapes and can comprise different materials. In still other embodiments, the profiling system can include other components adapted to selectively change the size and/or shape of the opening **181** of the distribution outlet **130**.

The illustrated profiling system **132** is adapted to locally vary along the transverse axis **60** the size and/or shape of the opening **181** of the distribution outlet **130**. The adjustment bolts **94**, **95** are in regular, spaced relationship to each other along the transverse axis **60** over the distribution outlet **130**. The adjustment bolts **94**, **95** are independently adjustable to locally vary the size and/or shape of the distribution outlet **130**.

The profiling system **132** can be used to locally vary the distribution outlet **130** so as to alter the flow pattern of the combined first and second flows of aqueous calcined gypsum slurry being distributed from the slurry distributor **120**. For example, the mid-line adjustment bolt **95** can be tightened down to constrict the transverse central midpoint **187** of the distribution outlet **130** to increase the edge flow angle away from the longitudinal axis **50** to facilitate spreading in the cross-machine direction **60** and to improve the slurry flow uniformity in the cross-machine direction **60**.

The profiling system **132** can be used to vary the size of the distribution outlet **130** along the transverse axis **60** and maintain the distribution outlet **130** in the new shape. The plate **90** can be made from a material that is suitably strong such that the plate **90** can withstand opposing forces exerted by the adjustment bolts **94**, **95** in response to adjustments made by the adjustment bolts **94**, **95** in urging the distribution outlet **130** into a new shape. The profiling system **132** can be used to help even out variations in the flow profile of the slurry (for example, as a result of different slurry densities and/or different feed inlet velocities) being discharged from the distribution outlet **130** such that the exit pattern of the slurry from the distribution conduit **128** is more uniform.

In other embodiments, the number of adjustment bolts can be varied such that the spacing between adjacent adjustment bolts changes. In other embodiments, such as where the width W_1 of the distribution outlet **130** is different, the number of adjustment bolts can also be varied to achieve a desired adjacent bolt spacing. In yet other embodiments, the spacing between adjacent bolts can vary along the transverse axis **60**, for example to provide greater locally-varying control at the side edges **183**, **185** of the distribution outlet **130**.

A slurry distributor constructed in accordance with principles of the present disclosure can comprise any suitable material. In some embodiments, a slurry distributor can comprise any suitable substantially rigid material which can include a suitable material which can allow the size and shape of the outlet to be modified using a profile system, for example. For example, a suitably rigid plastic, such as ultra-high molecular weight (UHMW) plastic, or metal can be used. In other embodiments, a slurry distributor constructed in accordance with principles of the present disclosure can be made from a flexible material, such as a suitable flexible plastic material, including poly vinyl chloride (PVC) or urethane, for example. In some embodiments, a slurry distributor constructed in accordance with principles of the present disclosure can include a single feed inlet, entry segment, and shaped duct which is in fluid communication with a distribution conduit.

A gypsum slurry distributor constructed in accordance with principles of the present disclosure can be used to help provide a wide cross machine distribution of aqueous calcined gypsum slurry to facilitate the spreading of high viscous/lower WSR gypsum slurries on a web of cover sheet material moving over a forming table. The gypsum slurry distribution system can be used to help control air-slurry phase separation, as well.

In accordance with another aspect of the present disclosure, a gypsum slurry mixing and dispensing assembly can include a slurry distributor constructed in accordance with principles of the present disclosure. The slurry distributor can be placed in fluid communication with a gypsum slurry mixer adapted to agitate water and calcined gypsum to form an aqueous calcined gypsum slurry. In one embodiment, the slurry distributor is adapted to receive a first flow and a second flow of aqueous calcined gypsum slurry from the gypsum slurry mixer and distribute the first and second flows of aqueous calcined gypsum slurry onto an advancing web.

The slurry distributor can comprise a part of, or act as, a discharge conduit of a conventional gypsum slurry mixer (e.g., a pin mixer) as is known in the art. The slurry distributor can be used with components of a conventional discharge conduit. For example, the slurry distributor can be used with components of a gate-canister-boot arrangement as known in the art or of the discharge conduit arrangements described in U.S. Pat. Nos. 6,494,609; 6,874,930; 7,007,914; and 7,296,919.

A slurry distributor constructed in accordance with principles of the present disclosure can advantageously be configured as a retrofit in an existing wallboard manufacturing system. The slurry distributor preferably can be used to replace a conventional single or multiple-branch boot used in conventional discharge conduits. This gypsum slurry distributor can be retrofitted to an existing slurry discharge conduit arrangement, such as that shown in U.S. Pat. No. 6,874,930 or 7,007,914, for example, as a replacement for the distal dispensing spout or boot. However, in some embodiments, the slurry distributor may, alternatively, be attached to one or more boot outlet(s).

Referring to FIGS. **4** and **5**, the slurry distributor **220** is similar to the slurry distributor **120** of FIGS. **1-3**, except that it is constructed from a substantially rigid material. The interior geometry **207** of the slurry distributor **220** of FIGS. **4** and **5** is similar to that of the slurry distributor **120** of FIGS. **1-3**, and like reference numerals are used to indicate like structure. The interior geometry **207** of the slurry distributor **207** is adapted to define a flow path for the gypsum slurry traveling therethrough which is of the manner of a streamline flow, undergoing reduced or substantially no air-liquid slurry phase separation and substantially without undergoing a vortex flow path.

In some embodiments, the slurry distributor **220** can comprise any suitable substantially rigid material which can include a suitable material which can allow the size and shape of the outlet **130** to be modified using a profile system, for example. For example, a suitably rigid plastic, such as UHMW plastic, or metal can be used.

Referring to FIG. **4**, the slurry distributor **220** has a two-piece construction. An upper piece **221** of the slurry distributor **220** includes a recess **227** adapted to receive a profiling system **132** therein. The two pieces **221**, **223** can be pivotally movable with respect to each other about a hinge **205** at the rear end thereof to allow for ready access to an interior **207** of the slurry distributor **220**. Mounting holes **229** are provided to facilitate the connection of the upper piece **221** and its mating lower piece **223**.

Referring to FIGS. **6-8**, another embodiment of a slurry distributor **320** constructed in accordance with principles of the present disclosure is shown which is constructed from a rigid material. The slurry distributor **320** of FIGS. **6-8** is similar to the slurry distributor **220** of FIGS. **4** and **5** except that the first and second feed inlets **324**, **325** and the first and second entry segments **336**, **337** of the slurry distributor **320** of FIGS. **6-8** are disposed at a feed angle θ with respect to the longitudinal axis or machine direction **50** of about 60° (see FIG. **7**).

The slurry distributor **320** has a two-piece construction including an upper piece **321** and its mating lower piece **323**. The two pieces **321**, **323** of the slurry distributor **320** can be secured together using any suitable technique, such as by using fasteners through a corresponding number of mounting holes **329** provided in each piece **321**, **323**, for example. The upper piece **321** of the slurry distributor **320** includes a recess **327** adapted to receive a profiling system **132** therein. The slurry distributor **320** of FIGS. **6-8** is similar in other respects to the slurry distributor **220** of FIGS. **4** and **5**.

Referring to FIGS. **9** and **10**, the lower piece **323** of the slurry distributor **320** of FIG. **6** is shown. The lower piece **323** defines a first portion **331** of the interior geometry **307** of the slurry distributor **320** of FIG. **6**. The upper piece **323** defines a symmetrical second portion of the interior geometry **307** such that when the upper and lower pieces **321**, **323** are mated together, as shown in FIG. **6**, they define the complete interior geometry **307** of the slurry distributor **320** of FIG. **6**.

Referring to FIG. **9**, the first and second shaped ducts **341**, **343** are adapted to receive the first and second flows of slurry moving in the first and second feed flow directions **390**, **391** and redirect the slurry flow direction by a change in direction angle α such that the first and second flows of slurry are conveyed into the distribution conduit **328** moving substantially in the outlet flow direction **392**, which is aligned with the machine direction or longitudinal axis **50**.

FIGS. **11** and **12** depict another embodiment of a slurry distributor support **300** for use with the slurry distributor **320** of FIG. **6**. The slurry distributor support **300** can include a top and bottom support plate **301**, **302** constructed from a suitably rigid material, such as metal, for example. The support plates **301**, **302** can be secured to the distributor through any suitable means. In use, the support plates **301**, **302** can help support the slurry distributor **320** in place over a machine line including a conveyor assembly supporting and transporting a moving cover sheet. The support plates **301**, **302** can be mounted to appropriate uprights placed on either side of the conveyor assembly.

FIGS. **13** and **14** depict yet another embodiment of a slurry distributor support **310** for use with the slurry distributor **320** of FIG. **6**, which also includes top and bottom support plates **311**, **312**. Cutouts **313**, **314**, **318** in the top support plate **311** can make the support **310** lighter than it would otherwise be and provide access to portions of the slurry distributor **320**, such as those portions accommodating mounting fasteners, for example. The slurry distributor support **310** of FIGS. **13** and **14** can be similar in other respects to the slurry distributor support **300** of FIGS. **11** and **12**.

FIGS. **15-19** illustrate another embodiment of a slurry distributor **420**, which is similar to the slurry distributor **320** of FIGS. **6-8**, except that it is constructed from a substantially flexible material. The slurry distributor **420** of FIGS. **15-19** also includes first and second feed inlets **324**, **325** and first and second entry segments **336**, **337** which are disposed at a feed angle θ with respect to the longitudinal axis or machine direction **50** of about 60° (see FIG. **7**). The interior geometry **307** of the slurry distributor **420** of FIGS. **15-19** is similar to that of the slurry distributor **320** of FIGS. **6-8**, and like reference numerals are used to indicate like structure.

FIGS. **17-19** progressively depict the interior geometry of the second entry segment **337** and the second shaped duct **343** of the slurry distributor **420** of FIGS. **15** and **16**. The cross-sectional areas **411**, **412**, **413**, **414** of the outer and inner guide channels **367**, **368** can become progressively smaller moving in a second flow direction **397** toward the distribution outlet **330**. The outer guide channel **367** can extend substantially along the outer wall **357** of the second shaped duct **343** and along the sidewall **353** of the distribution conduit **328** to the distribution outlet **330**. The inner guide channel **368** is adjacent the inner wall **358** of the second shaped duct **343** and terminates at the peak **375** of the bisected connector segment **339**. The slurry distributor **420** of FIGS. **15-19** is similar in other respects to the slurry distributor **120** of FIG. **1** and the slurry distributor **320** of FIG. **6**.

Referring to FIGS. **20** and **21**, the illustrated embodiment of the slurry distributor **420** is made from a flexible material, such as PVC or urethane, for example. A slurry distributor support **400** can be provided to help support the slurry distributor **420**. The slurry distributor support **400** can include a support member, which in the illustrated embodiment is in the form of a bottom support tray **401** filled with a suitable supporting medium **402** which defines a supporting surface **404**. The supporting surface **404** is configured to substantially conform to at least a portion of an exterior of at least one of the feed conduit **322** and the distribution conduit **328** to help limit the amount of relative movement between the slurry distributor **420** and the support tray **401**. In some embodiments, the supporting surface **404** can also help maintain the interior geometry of the slurry distributor **420** through which a slurry will flow.

The slurry distributor support **400** can also include a movable support assembly **405** disposed in spaced relationship to bottom support tray **401**. The movable support assembly **405** can be positioned above the slurry distributor **420** and adapted to be placed in supporting relationship with the slurry distributor **420** to help maintain the interior geometry **307** of the slurry distributor in a desired configuration.

The movable support assembly **405** can include a support frame **407** and a plurality of support segments **415, 416, 417, 418, 419** which are movably supported by the support frame **407**. The support frame **407** can be mounted to at least one of the bottom support tray **401** or a suitably arranged upright or uprights to retain the support frame **407** in fixed relationship to the bottom support tray **401**.

In embodiments, at least one support segment **415, 416, 417, 418, 419** is independently movable relative to another support segment **415, 416, 417, 418, 419**. In the illustrated embodiment, each support segment **415, 416, 417, 418, 419** can be independently movable relative to the support frame **407** over a predetermined range of travel. In embodiments, each support segment **415, 416, 417, 418, 419** is movable over a range of travel such that each support segment is in a range of positions over which the respective support segment **415, 416, 417, 418, 419** is in increasing compressive engagement with a portion of at least one of the feed conduit **322** and the distribution conduit **328**.

The position of each support segment **415, 416, 417, 418, 419** can be adjusted to place the support segments **415, 416, 417, 418, 419** in compressive engagement with at least a portion of the slurry distributor **420**. Each support segment

415, 416, 417, 418, 419 can be independently adjusted to place each support segment 415, 416, 417, 418, 419 either in further compressive engagement with at least a portion of the slurry distributor 420, thereby locally compressing the interior of the slurry distributor 420, or in reduced compressive engagement with at least a portion of the slurry distributor 420, thereby allowing the interior of the slurry distributor 420 to expand outwardly, such as in response to aqueous gypsum slurry flowing therethrough.

In the illustrated embodiment, each of the support segments 415, 416, 417 is movable over a range of travel along the vertical axis 55. In other embodiments, at least one of the support segments can be movable along a different line of action.

The movable support assembly 405 includes a clamping mechanism 408 associated with each support segment 415, 416, 417, 418, 419. Each clamping mechanism 408 can be adapted to selectively retain the associated support segment 415, 416, 417, 418, 419 in a selected position relative to the support frame 407.

In the illustrated embodiment, a rod 409 is mounted to each support segment 415, 416, 417, 418, 419 and extends upwardly through a corresponding opening in the support frame 407. Each clamping mechanism 408 is mounted to the support frame 407 and is associated with one of the rods 409 projecting from a respective support segment 415, 416, 417, 418, 419. Each clamping mechanism 408 can be adapted to selectively retain the associated rod 409 in fixed relationship to the support frame 407. The illustrated clamping mechanisms 408 are conventional lever-actuated clamps which encircle the respective rod 409 and allow for infinitely variable adjustment between the clamping mechanism 408 and the associated rod 409.

As one skilled in the art will appreciate, any suitable clamping mechanism 408 can be used in other embodiments. In some embodiments, each associated rod 409 can be moved via a suitable actuator (either hydraulic or electric, e.g.) which is controlled via a controller. The actuator can function as a clamping mechanism by retaining the associated support segment 415, 416, 417, 418, 419 in a fixed position relative to the support frame 407.

Referring to FIG. 21, the support segments 415, 416, 417, 418, 419 can each include a contacting surface 501, 502, 503, 504, 505 which is configured to substantially conform to a surface portion of the desired geometric shape of at least one of the feed conduit 322 and the distribution conduit 328 of the slurry distributor 420. In the illustrated embodiment, a distributor conduit support segment 415 is provided which includes a contacting surface 501 which conforms to the exterior and interior shape of a portion of the distributor conduit 328 over which the distributor conduit support segment 415 is disposed. A pair of shaped duct support segments 416, 417 is provided which respectively include a contacting surface 502, 503 which conforms to the exterior and interior shape of a portion of the first and the second shaped ducts 341, 343, respectively, over which the shaped duct support segments 416, 417 are disposed. A pair of entry support segments 418, 419 is provided which respectively include a contacting surface 504, 505 which conforms to the exterior and interior shape of a portion of the first and the second entry segments 336, 337, respectively, over which the shaped duct support segments 418, 419 are disposed. The contacting surfaces 501, 502, 503, 504, 505 are adapted to be placed in contacting relationship with a selected portion of the slurry distributor 420 to help maintain the contacted portion of the slurry distributor 420 in position to help define the interior geometry 307 of the slurry distributor 420.

In use, the movable support assembly 405 can be operated to place each support segment 415, 416, 417, 418, 419 independently in a desired relationship with the slurry distributor 420. The support segments 415, 416, 417, 418, 419 can help maintain the interior geometry 307 of the slurry distributor 420 to promote the flow of slurry therethrough and to help ensure the volume defined by the interior geometry 307 is substantially filled with slurry during use. The location of the particular contacting surface of a given support segment 415, 416, 417, 418, 419 can be adjusted to modify locally the interior geometry of the slurry distributor 420. For example, the distributor conduit support segment 415 can be moved along the vertical axis 55 closer to the bottom support tray 401 to decrease the height of the distribution conduit 328 in an area over which the distributor conduit support segment 415 is.

In other embodiments, the number of support segments can be varied. In still other embodiments, the size and/or shape of a given support segment can be varied.

Any suitable technique for making a slurry distributor constructed in accordance with principles of the present disclosure can be used. For example, in embodiments where the slurry distributor is made from a flexible material, such as PVC or urethane, a multi-piece mold can be used. In some embodiments, the mold piece areas are about 150% or less than the area of the molded slurry distributor through which the mold piece is being pulled during removal, about 125% or less in other embodiments, about 115% or less in still other embodiments, and about 110% or less in yet other embodiments.

Referring to FIGS. 22 and 23, an embodiment of a multi-piece mold 550 suitable for use in making the slurry distributor 120 of FIG. 1 from a flexible material, such as PVC or urethane is shown. The illustrated multi-piece mold 550 includes five mold segments 551, 552, 553, 554, 555. The mold segments 551, 552, 553, 554, 555 of the multi-piece mold 550 can be made from any suitable material, such as aluminum, for example.

Each mold segment 551, 552, 553, 554, 555 includes an exterior surface configured to define at least a portion of an interior surface of a slurry distributor. The mold segments 551, 552, 553, 554, 555 are configured such that when the mold segments 551, 552, 553, 554, 555 are assembled together to form the multi-piece mold 550, the assembled mold segments define a substantially continuous exterior surface 580 adapted to be a negative image of an interior flow region of a slurry distributor molded thereupon, in this case the slurry distributor 120 of FIG. 1.

Each mold segment 551, 552, 553, 554, 555 has a maximum cross-sectional area in a plane substantially transverse to a direction of movement of the mold segment along a removal path out of a respective opening of the molded slurry distributor 120 which is in overlying relationship to the mold 550 when being made. The maximum cross-sectional area of each mold segment 551, 552, 553, 554, 555 is up to about 150% of the smallest area of the interior flow region of the molded slurry distributor 120 through which the respective mold segment 551, 552, 553, 554, 555 traverses when moving along the respective removal path.

In embodiments, the maximum cross-sectional area of each mold segment 551, 552, 553, 554, 555 is up to about 125% of the smallest area of the interior flow region of the molded slurry distributor 120 through which the respective mold segment 551, 552, 553, 554, 555 traverses when moving along the respective removal path, in a range from greater than to about 150% of the smallest area of the interior flow region of the molded slurry distributor 120 through which the respective mold segment **551**, **552**, **553**, **554**, **555** traverses when moving along the respective removal path in other embodiments, about 115% or less in still other embodiments, and about 110% or less in yet other embodiments.

In the illustrated embodiment, the distributor conduit mold segment **551** is configured to define the interior flow geometry of the distributor conduit **128**. The first and second shaped duct mold segments **552**, **553** are configured to define the interior flow geometry of the first and the second shaped ducts **141**, **143**. The first and second entry mold segments **554**, **555** define the interior flow geometry of the first entry segment **136** and the first feed inlet **124** and of the second entry segment **137** and the second feed inlet **125**, respectively. In other embodiments, the multi-piece mold can include a different number of mold segments and/or the mold segments can have different shapes and/or sizes.

FIGS. **22**A-E depict various views of the first entry mold segment **554**. It should be understood that the second entry mold segment **555** is substantially a mirror image of the first entry mold segment **554**. FIGS. **22**F-I depict various views of the first shaped duct mold segment **552**. It should be understood that the second shaped duct mold segment **553** is substantially a mirror image of the first shaped duct mold segment **552**. FIGS. **22**J and K show additional views of the distributor conduit mold segment **551**.

Referring to FIG. **23**, the distributor conduit mold segment **551** has a removal path **581** which is substantially aligned with the longitudinal axis **50**. The distributor conduit mold segment **551** can be removed from the interior flow region of the slurry distributor **120** molded upon it by disassembling the distributor conduit mold segment **551** from the first and second shaped duct mold segments **552**, **553** and the first and second entry mold segments **554**, **555** and moving the distributor conduit mold segment **551** from its assembled position, shown in FIG. **23**, along the removal path **581** out of the opening **181** of the discharge outlet **130**.

The first shaped duct mold segment **552** and the first entry mold segment **554** each has a removal path **582**, **584**, respectively, which is substantially aligned with the transverse axis **60**. The first entry mold segment **554** can be removed from the interior flow region of the slurry distributor **120** molded upon it by disassembling the first entry mold segment **554** from the first shaped duct mold segment **552** and the distributor conduit mold segment **551** and moving the first entry mold segment **554** from its assembled position, shown in FIG. **23**, along the removal path **584** out of the opening **134** of the first feed inlet **124**. Once the first entry mold segment **554** is removed, the first shaped duct mold segment **552** can be removed from the interior flow region of the slurry distributor **120** molded upon it by disassembling the first shaped duct mold segment **552** from the distributor conduit mold segment **551** and moving the first shaped duct mold segment **552** from its assembled position, shown in FIG. **23**, along the removal path **582** out of the opening **134** of the first feed inlet **124**.

The second shaped duct mold segment **553** and the second entry mold segment **555** each has a removal path **583**, **585**, respectively, which is substantially aligned with the transverse axis **60**. The second entry mold segment **555** can be removed from the interior flow region of the slurry distributor **120** molded upon it by disassembling the second entry mold segment **555** from the second shaped duct mold segment **553** and the distributor conduit mold segment **551** and moving the second entry mold segment **555** from its assembled position, shown in FIG. **23**, along the removal path **585** out of the opening **135** of the second feed inlet **125**. Once the second entry mold segment **555** is removed, the second shaped duct mold segment **553** can be removed from the interior flow region of the slurry distributor **120** molded upon it by disassembling the second shaped duct mold segment **553** from the distributor conduit mold segment **551** and moving the second shaped duct mold segment **553** from its assembled position, shown in FIG. **23**, along the removal path **583** out of the opening **135** of the second feed inlet **125**.

In embodiments, at least two mold segments **551**, **552**, **553**, **554**, **555** define a respective passage therein where the passages are configured to be aligned with each other when the respective mold segments **551**, **552**, **553**, **554**, **555** are disposed in an assembled position so that the mold segment is disposed to define at least a portion of the interior surface of the slurry distributor. Suitable connecting rods adapted to be inserted through the aligned passages can be provided to interconnect the mold segments **551**, **552**, **553**, **554**, **555**. In embodiments, at least three mold segments **551**, **552**, **553**, **554**, **555** can be interconnected with a suitable connecting rod.

Referring to FIG. **22**, connecting bolts **571**, **572**, **573** can be inserted through passages in two or more mold segments to interlock and align the mold segments **551**, **552**, **553**, **554**, **555** such that a substantially continuous exterior surface **580** of the multi-piece mold **550** is defined. In some embodiments, a distal portion **575** of the connecting bolts **571**, **572**, **573** includes an external thread that is configured to threadingly engage one of the mold segments **551**, **552**, **553**, **554**, **555** to interconnect at least two of the mold segments **551**, **552**, **553**, **554**, **555**.

Each of the outer distributor conduit connecting bolts **571** extends through aligned passages in the distributor conduit mold segment **551** and respectively through a shoulder portion **588**, **589** of the first and second entry mold segments **554**, **555** and the first and second shaped duct mold segments **552**, **553**. Each of the inner distributor conduit connecting bolts **572** extends through aligned passages in the distributor conduit mold segment **551** and respectively through the first and second shaped duct mold segments **552**, **553**. The first feed conduit connecting bolt **573** extends through aligned passages in the first entry mold segment **554** and the first shaped duct mold segment **552**. The second feed conduit connecting bolt **573** extends through aligned passages in the second entry mold segment **555** and the second shaped duct mold segment **553**.

Referring to FIG. **23**, each mold segment **551**, **552**, **553**, **554**, **555** includes at least one mating surface **591**, **592**, **593**, **594**, **595**, **596**, **597** configured to have a shape that is complementary to a shape of the mating surface **591**, **592**, **593**, **594**, **595**, **596**, **597** of at least one other mold segment **551**, **552**, **553**, **554**, **555**. In this way pairs of mating surfaces **591**, **592**, **593**, **594**, **595**, **596**, **597** can be joined together to place the mold segments **551**, **552**, **553**, **554**, **555** in the assembled position, as shown in FIG. **23**.

In the illustrated embodiment, the mating surface **591** of the distributor conduit mold segment **551** matingly complements and is adjoined with the first mating surfaces **592**, **593** of the first and second shaped duct mold segments **552**, **553**, respectively. The mating surface **594** of the first entry mold segment **554** matingly complements and is adjoined with the second mating surface **596** of the first shaped duct mold segment **552**. The mating surface **595** of the second entry mold segment **555** matingly complements and is adjoined with the second mating surface **597** of the second shaped duct mold segment **553**.

The exterior surface **580** of the multi-piece mold **550** is configured to define the interior geometry of the molded slurry distributor **120** so that flashing at the joints is reduced. The assembled multi-piece mold **550** can dipped into a solution of flexible material, such as PVC or urethane, such that the mold **550** is completely submersed in the solution. The mold **550** can then be removed from the dipped material. An amount of the solution can adhere to the exterior surface **580** of the multi-piece mold **550** which will constitute the molded slurry distributor **120** once the solution changes to a solid form. In embodiments, the multi-piece mold **550** can be used in any suitable dipping process to form the molded piece.

The connecting bolts **571**, **572**, **573** can be removed to disassemble the multi-piece mold **550** during removal of the mold **550** from the interior of the molded slurry distributor **120**. Access to the connecting bolts **571**, **572**, **573** can be provided through the respective openings **130**, **143**, **135** of the slurry distributor which are in fluid communication with the interior flow region of the slurry distributor **120**.

By making the mold **550** out of multiple separate aluminum pieces—in the illustrated embodiment, five pieces—that have been designed to fit together to provide the desired interior flow geometry, the mold segments **551**, **552**, **553**, **554**, **555** can be disengaged from each other and pulled out from the solution once it has begun to set but while it is still warm. At sufficiently-high temperatures, the flexible material is pliable enough to pull larger calculated areas of the aluminum mold pieces **551**, **552**, **553**, **554**, **555** through the smaller calculated areas of the molded slurry distributor **120** without tearing it. In some embodiments, the largest mold piece area is up to about 150% of the smallest area of the molded slurry distributor cavity area through which the particular mold piece traverses transversely during the removal process, up to about 125% in other embodiments, up to about 115% in still other embodiments, and up to about 110% in yet other embodiments.

Referring to FIG. **24**, an embodiment of a multi-piece mold **650** suitable for use in making the slurry distributor **320** of FIG. **6** from a flexible material, such as PVC or urethane is shown. The illustrated multi-piece mold **650** includes five mold segments **651**, **652**, **653**, **654**, **655**. The mold segments **651**, **652**, **653**, **654**, **655** of the multi-piece mold **550** can be made from any suitable material, such as aluminum, for example. The mold segments **651**, **652**, **653**, **654**, **655** are shown in a disassembled condition in FIG. **24**.

Connecting bolts can be used to removably connect the mold segments **651**, **652**, **653**, **654**, **655** together to assemble the mold **650** such that a substantially continuous exterior surface of the multi-piece mold **650** is defined. The exterior surface of the multi-piece mold **650** defines the internal flow geometry of the slurry distributor **220** of FIG. **6**. The mold **650** can be similar in construction to the mold **550** of FIGS. **22** and **23** in that each piece of the mold **650** of FIG. **24** is constructed such that its area is within a predetermined amount of the smallest area of the molded slurry distributor **220** through which the mold piece must traverse when it is being removed (e.g., greater than the smallest area of the molded slurry distributor cavity area through which the particular mold piece traverses transversely during the removal process in some embodiments up to about 150% in other embodiments, up to about 150% of the smallest area of the molded slurry distributor cavity area through which the particular mold piece traverses transversely during the removal process in some embodiments, up to about 125% in other embodiments, up to about 115% in still other embodiments, and up to about 110% in yet other embodiments). The multi-piece mold **650** of FIG. **24** can be similar in other respects to the multi-piece mold **550** of FIGS. **22** and **23** in other respects.

Various embodiments of a method of making a slurry distributor can be practiced using an embodiment of a multi-piece mold according to principles of the present disclosure. In one embodiment, a plurality of mold segments of a multi-piece mold is assembled to define an exterior surface of the multi-piece mold. The assembled multi-piece mold is dipped into a solution of flexible material such that at least a portion of the multi-piece mold is submersed in the solution. The multi-piece mold is removed from the solution such that a layer of solution adheres substantially around the exterior surface of the multi-piece mold. The solution is allowed to cure such that an at least partially-solidified molded slurry distributor is formed around the multi-piece mold. The molded slurry distributor has an interior surface defining an interior flow region. The interior surface of the molded slurry distributor is in contacting relationship with the exterior surface of the multi-piece mold. The molded slurry distributor defines at least two openings each in fluid communication with the interior flow region.

The multi-piece mold is disassembled by removing each mold segment from the interior flow region of the slurry distributor through one of the openings of the molded slurry distributor such that each mold segment travels along a respective removal path from its assembled position in the assembled multi-piece mold out through the respective opening. Each mold segment has a maximum cross-sectional area in a plane substantially transverse to the direction of movement of the mold segment along the removal path out of the respective opening of the molded slurry distributor. The maximum cross-sectional area of each mold segment is up to about 150% of the smallest area of the interior flow region of the molded slurry distributor through which the mold segment traverses when moving along the respective removal path. In embodiments, at least a portion of the interior surface of the molded slurry distributor is substantially a negative image of at least a portion of the exterior surface of the multi-piece mold.

In embodiments, at least two mold segments can be assembled together by aligning a respective passage defined in the mold segments and inserting a connecting rod through the aligned passages to interconnect the mold segments. In some embodiments, at least three mold segments are assembled together by inserting a connecting rod through aligned passages defined therein. In embodiments, each passage can be aligned with at least one respective opening of the molded slurry distributor to allow for the removal of the associated connecting rod from the passage.

In embodiments, at least one mold segment can be removed from the flow region of the slurry distributor through a different opening of the molded slurry distributor than at least one other mold segment. At least two mold segments can be removed from the interior flow region of the slurry distributor by following a removal path through the opening of the first feed inlet, and at least one mold segment can be removed from the interior flow region of the slurry distributor by following a removal path through the opening of the distribution outlet.

Referring to FIGS. **25** and **26**, an embodiment of a mold **750** for use in making one of the pieces **221**, **223** of the two-piece slurry distributor **220** of FIG. **4** is shown. Referring to FIG. **25**, mounting bore-defining elements **852** can be included to define mounting bores in the piece of the two-piece slurry distributor **220** of FIG. **34** being made to facilitate its connection with the other piece.

Referring to FIGS. **25** and **26**, the mold **750** includes a mold surface **754** projecting from a bottom surface **756** of the mold **750**. A boundary wall **756** extends along the vertical axis and defines the depth of the mold. The mold surface **754** is disposed within the boundary wall **756**. The boundary wall **756** is configured to allow the volume of a cavity **758** defined within the boundary wall to be filled with molten mold material such that the mold surface **754** is immersed. The mold surface **754** is configured to be a negative image of the interior flow geometry defined by the particular piece of the two-piece distributor being molded.

In use, the cavity **758** of the mold **750** can be filled with a molten material such that the mold surface is immersed and the cavity **758** is filled with molten material. The molten material can be allowed to cool and removed from the mold **750**. Another mold can be used to form the mating piece of the slurry distributor **220** of FIG. **4**.

Referring to FIG. **27**, an embodiment of a gypsum slurry mixing and dispensing assembly **810** includes a gypsum slurry mixer **912** in fluid communication with a slurry distributor **820** similar to the slurry distributor **320** shown in FIG. **6**. The gypsum slurry mixer **812** is adapted to agitate water and calcined gypsum to form an aqueous calcined gypsum slurry. Both the water and the calcined gypsum can be supplied to the mixer **812** via one or more inlets as is known in the art. Any suitable mixer (e.g., a pin mixer) can be used with the slurry distributor.

The slurry distributor **820** is in fluid communication with the gypsum slurry mixer **812**. The slurry distributor **820** includes a first feed inlet **824** adapted to receive a first flow of aqueous calcined gypsum slurry from the gypsum slurry mixer **812** moving in a first feed direction **890**, a second feed inlet **825** adapted to receive a second flow of aqueous calcined gypsum slurry from the gypsum slurry mixer **812** moving in a second feed direction **891**, and a distribution outlet **830** in fluid communication with both the first and the second feed inlets **824**, **825** and adapted such that the first and second flows of aqueous calcined gypsum slurry discharge from the slurry distributor **820** through the distribution outlet **830** substantially along a machine direction **50**.

The slurry distributor **820** includes a feed conduit **822** in fluid communication with a distribution conduit **828**. The feed conduit includes the first feed inlet **824** and the second feed inlet **825** disposed in spaced relationship to the first feed inlet **824**, which are both disposed at a feed angle θ of about 60° with respect to the machine direction **50**. The feed conduit **822** includes structure therein adapted to receive the first and second flows of slurry moving in the first and second feed flow direction **890**, **891** and redirect the slurry flow direction by a change in direction angle α (see FIG. **9**) such that the first and second flows of slurry are conveyed into the distribution conduit **828** moving substantially in the outlet flow direction **892**, which is substantially aligned with the machine direction **50**. The first and second feed inlets **824**, **825** each has an opening with a cross-sectional area, and the entry portion **852** of the distribution conduit **828** has an opening with a cross-sectional area which is greater than the sum of the cross-sectional areas of the openings of the first and second feed inlets **824**, **825**.

The distribution conduit **828** extends generally along the longitudinal axis or machine direction **50**, which is substantially perpendicular to a transverse axis **60**. The distribution conduit **828** includes an entry portion **852** and the distribution outlet **830**. The entry portion **852** is in fluid communication with the first and second feed inlets **824**, **825** of the feed conduit **822** such that the entry portion **852** is adapted to receive both the first and the second flows of aqueous calcined gypsum slurry therefrom. The distribution outlet **830** is in fluid communication with the entry portion **852**. The distribution outlet **830** of the distribution conduit **828** extends a predetermined distance along the transverse axis **60** to facilitate the discharge of the combined first and second flows of aqueous calcined gypsum slurry in the cross-machine direction or along the transverse axis **60**. The slurry distributor **820** can be similar in other respects to the slurry distributor **320** of FIG. **6**.

A delivery conduit **814** is disposed between and in fluid communication with the gypsum slurry mixer **812** and the slurry distributor **820**. The delivery conduit **814** includes a main delivery trunk **815**, a first delivery branch **817** in fluid communication with the first feed inlet **824** of the slurry distributor **820**, and a second delivery branch **818** in fluid communication with the second feed inlet **825** of the slurry distributor **820**. The main delivery trunk **815** is in fluid communication with both the first and second delivery branches **817**, **818**. In other embodiments, the first and second delivery branches **817**, **818** can be in independent fluid communication with the gypsum slurry mixer **812**.

The delivery conduit **814** can be made from any suitable material and can have different shapes. In some embodiments, the delivery conduit **814** can comprise a flexible conduit.

An aqueous foam supply conduit **821** can be in fluid communication with at least one of the gypsum slurry mixer **812** and the delivery conduit **814**. An aqueous foam from a source can be added to the constituent materials through the foam supply conduit **821** at any suitable location downstream of the mixer **812** and/or in the mixer **812** itself to form a foamed gypsum slurry that is provided to the slurry distributor **220**. In the illustrated embodiment, the foam supply conduit **821** is disposed downstream of the gypsum slurry mixer **812**. In the illustrated embodiment, the aqueous foam supply conduit **821** has a manifold-type arrangement for supplying foam to an injection ring or block associated with the delivery conduit **814** as described in U.S. Pat. No. 6,874,930, for example.

In other embodiments, one or more foam supply conduits can be provided that are in fluid communication with the mixer **812**. In yet other embodiments, the aqueous foam supply conduit(s) can be in fluid communication with the gypsum slurry mixer alone. As will be appreciated by those skilled in the art, the means for introducing aqueous foam into the gypsum slurry in the gypsum slurry mixing and dispensing assembly **810**, including its relative location in the assembly, can be varied and/or optimized to provide a uniform dispersion of aqueous foam in the gypsum slurry to produce board that is fit for its intended purpose.

Any suitable foaming agent can be used. Preferably, the aqueous foam is produced in a continuous manner in which a stream of the mix of foaming agent and water is directed to a foam generator, and a stream of the resultant aqueous foam leaves the generator and is directed to and mixed with the calcined gypsum slurry. Some examples of suitable foaming agents are described in U.S. Pat. Nos. 5,683,635 and 5,643,510, for example.

When the foamed gypsum slurry sets and is dried, the foam dispersed in the slurry produces air voids therein which act to lower the overall density of the wallboard. The amount of foam and/or amount of air in the foam can be varied to adjust the dry board density such that the resulting wallboard product is within a desired weight range.

One or more flow-modifying elements **823** can be associated with the delivery conduit **814** and adapted to control the first and the second flows of aqueous calcined gypsum slurry from the gypsum slurry mixer **812**. The flow-modifying element(s) **823** can be used to control an operating characteristic of the first and second flows of aqueous calcined gypsum slurry. In the illustrated embodiment of FIG. **27**, the flow-modifying element(s) **823** is associated with the main delivery trunk **815**. Examples of suitable flow-modifying elements include volume restrictors, pressure reducers, constrictor valves, canisters, etc., including those described in U.S. Pat. Nos. 6,494,609; 6,874,930; 7,007,914; and 7,296,919, for example.

The main delivery trunk **815** can be joined to the first and second delivery branches **817**, **818** via a suitable Y-shaped flow splitter **819**. The flow splitter **819** is disposed between the main delivery trunk **815** and the first delivery branch **817** and between the main delivery trunk **815** and the second delivery branch **818**. In some embodiments, the flow splitter **819** can be adapted to help split the first and second flows of gypsum slurry such that they are substantially equal. In other embodiments, additional components can be added to help regulate the first and second flows of slurry.

In use, an aqueous calcined gypsum slurry is discharged from the mixer **812**. The aqueous calcined gypsum slurry from the mixer **812** is split in the flow splitter **819** into the first flow of aqueous calcined gypsum slurry and the second flow of aqueous calcined gypsum slurry. The aqueous calcined gypsum slurry from the mixer **812** can be split such that the first and second flows of aqueous calcined gypsum slurry are substantially balanced.

Referring to FIG. **28**, another embodiment of a gypsum slurry mixing and dispensing assembly **910** is shown. The gypsum slurry mixing and dispensing assembly **910** includes a gypsum slurry mixer **912** in fluid communication with a slurry distributor **920**. The gypsum slurry mixer **912** is adapted to agitate water and calcined gypsum to form an aqueous calcined gypsum slurry. The slurry distributor **920** can be similar in construction and function to the slurry distributor **320** of FIG. **6**.

A delivery conduit **914** is disposed between and in fluid communication with the gypsum slurry mixer **912** and the slurry distributor **920**. The delivery conduit **914** includes a main delivery trunk **915**, a first delivery branch **917** in fluid communication with the first feed inlet **924** of the slurry distributor **920**, and a second delivery branch **918** in fluid communication with the second feed inlet **925** of the slurry distributor **920**.

The main delivery trunk **915** is disposed between and in fluid communication with the gypsum slurry mixer **912** and both the first and the second delivery branches **917**, **918**. An aqueous foam supply conduit **921** can be in fluid communication with at least one of the gypsum slurry mixer **912** and the delivery conduit **914**. In the illustrated embodiment, the aqueous foam supply conduit **921** is associated with the main delivery trunk **915** of the delivery conduit **914**.

The first delivery branch **917** is disposed between and in fluid communication with the gypsum slurry mixer **912** and the first feed inlet **924** of the slurry distributor **920**. At least one first flow-modifying element **923** is associated with the first delivery branch **917** and is adapted to control the first flow of aqueous calcined gypsum slurry from the gypsum slurry mixer **912**.

The second delivery branch **918** is disposed between and in fluid communication with the gypsum slurry mixer **912** and the second feed inlet **925** of the slurry distributor **920**. At least one second flow-modifying element **927** is associated with the second delivery branch **918** and is adapted to control the second flow of aqueous calcined gypsum slurry from the gypsum slurry mixer **912**.

The first and second flow-modifying elements **923**, **927** can be operated to control an operating characteristic of the first and second flows of aqueous calcined gypsum slurry. The first and second flow-modifying elements **923**, **927** can be independently operable. In some embodiments, the first and second flow-modifying elements **923**, **927** can be actuated to deliver first and second flows of slurries that alternate between a relatively slower and relatively faster average velocity in opposing fashion such that at a given time the first slurry has an average velocity that is faster than that of the second flow of slurry and at another point in time the first slurry has an average velocity that is slower than that of the second flow of slurry.

As one of ordinary skill in the art will appreciate, one or both of the webs of cover sheet material can be pre-treated with a very thin relatively denser layer of gypsum slurry (relative to the gypsum slurry comprising the core), often referred to as a skim coat in the art, and/or hard edges, if desired. To that end, the mixer **912** includes a first auxiliary conduit **929** that is adapted to deposit a stream of dense aqueous calcined gypsum slurry that is relatively denser than the first and second flows of aqueous calcined gypsum slurry delivered to the slurry distributor (i.e., a "face skim coat/hard edge stream"). The first auxiliary conduit **929** can deposit the face skim coat/hard edge stream upon a moving web of cover sheet material upstream of a skim coat roller **931** that is adapted to apply a skim coat layer to the moving web of cover sheet material and to define hard edges at the periphery of the moving web by virtue of the width of the roller **931** being less than the width of the moving web as is known in the art. Hard edges can be formed from the same dense slurry that forms the thin dense layer by directing portions of the dense slurry around the ends of the roller used to apply the dense layer to the web.

The mixer **912** can also include a second auxiliary conduit **933** adapted to deposit a stream of dense aqueous calcined gypsum slurry that is relatively denser than the first and second flows of aqueous calcined gypsum slurry delivered to the slurry distributor (i.e., a "back skim coat stream"). The second auxiliary conduit **933** can deposit the back skim coat stream upon a second moving web of cover sheet material upstream (in the direction of movement of the second web) of a skim coat roller **937** that is adapted to apply a skim coat layer to the second moving web of cover sheet material as is known in the art (see FIG. **29** also).

In other embodiments, separate auxiliary conduits can be connected to the mixer to deliver one or more separate edge streams to the moving web of cover sheet material. Other suitable equipment (such as auxiliary mixers) can be provided in the auxiliary conduits to help make the slurry therein denser, such as by mechanically breaking up foam in the slurry and/or by chemically breaking down the foam through use of a suitable de-foaming agent.

In yet other embodiments, first and second delivery branches can each include a foam supply conduit therein which are respectively adapted to independently introduce aqueous foam into the first and second flows of aqueous calcined gypsum slurry delivered to the slurry distributor. In still other embodiments, a plurality of mixers can be provided to provide independent streams of slurry to the first and second feed inlets of a slurry distributor constructed in accordance with principles of the present disclosure. It will be appreciated that other embodiments are possible.

The gypsum slurry mixing and dispensing assembly **910** of FIG. **28** can be similar in other respects to the gypsum slurry mixing and dispensing assembly **810** of FIG. **27**. It is further contemplated that other slurry distributors constructed in accordance with principles of the present disclosure can be used in other embodiments of a gypsum slurry mixing and dispensing assembly as described herein.

Referring to FIG. **29**, an exemplary embodiment of a wet end **1011** of a gypsum wallboard manufacturing line is shown. The wet end **1011** includes a gypsum slurry mixing and dispensing assembly **1010** having a gypsum slurry mixer **1012** in fluid communication with a slurry distributor **1020** similar in construction and function to the slurry distributor **320** of FIG. **6**, a hard edge/face skim coat roller **1031** disposed upstream of the slurry distributor **1020** and supported over a forming table **1038** such that a first moving web **1039** of cover sheet material is disposed therebetween, a back skim coat roller **1037** disposed over a support element **1041** such that a second moving web **1043** of cover sheet material is disposed therebetween, and a forming station **1045** adapted to shape the preform into a desired thickness. The skim coat rollers **1031**, **1037**, the forming table **1038**, the support element **1041**, and the forming station **1045** can all comprise conventional equipment suitable for their intended purposes as is known in the art. The wet end **1011** can be equipped with other conventional equipment as is known in the art.

In another aspect of the present disclosure, a slurry distributor constructed in accordance with principles of the present disclosure can be used in a variety of manufacturing processes. For example, in one embodiment, a slurry distribution system can be used in a method of preparing a gypsum product. A slurry distributor can be used to distribute an aqueous calcined gypsum slurry upon the first advancing web **1039**.

Water and calcined gypsum can be mixed in the mixer **1012** to form the first and second flows **1047**, **1048** of aqueous calcined gypsum slurry. In some embodiments, the water and calcined gypsum can be continuously added to the mixer in a water-to-calcined gypsum ratio from about 0.5 to about 1.3, and in other embodiments of about 0.75 or less.

Gypsum board products are typically formed "face down" such that the advancing web **1039** serves as the "face" cover sheet of the finished board. A face skim coat/hard edge stream **1049** (a layer of denser aqueous calcined gypsum slurry relative to at least one of the first and second flows of aqueous calcined gypsum slurry) can be applied to the first moving web **1039** upstream of the hard edge/face skim coat roller **1031**, relative to the machine direction **1092**, to apply a skim coat layer to the first web **1039** and to define hard edges of the board.

The first flow **1047** and the second flow **1048** of aqueous calcined gypsum slurry are respectively passed through the first feed inlet **1024** and the second feed inlet **1025** of the slurry distributor **1020**. The first and second flows **1047**, **1048** of aqueous calcined gypsum slurry are combined in the slurry distributor **1020**. The first and second flows **1047**, **1048** of aqueous calcined gypsum slurry move along a flow path through the slurry distributor **1020** in the manner of a streamline flow, undergoing minimal or substantially no air-liquid slurry phase separation and substantially without undergoing a vortex flow path.

The first moving web **1039** moves along the longitudinal axis **50**. The first flow **1047** of aqueous calcined gypsum slurry passes through the first feed inlet **1024**, and the second flow **1048** of aqueous calcined gypsum slurry passes through the second feed inlet **1025**. The distribution conduit **1028** is positioned such that it extends along the longitudinal axis **50** which substantially coincides with the machine direction **1092** along which the first web **1039** of cover sheet material moves. Preferably, the central midpoint of the distribution outlet **1030** (taken along the transverse axis/cross-machine direction **60**) substantially coincides with the central midpoint of the first moving cover sheet **1039**. The first and second flows **1047**, **1048** of aqueous calcined gypsum slurry combine in the slurry distributor **1020** such that the combined first and second flows **1051** of aqueous calcined gypsum slurry pass through the distribution outlet **1030** in a distribution direction **1093** generally along the machine direction **1092**.

In some embodiments, the distribution conduit **1028** is positioned such that it is substantially parallel to the plane defines by the longitudinal axis **50** and the transverse axis **60** of the first web **1039** moving along the forming table. In other embodiments, the entry portion of the distribution conduit can be disposed vertically lower or higher than the distribution outlet **1030** relative to the first web **1039**.

The combined first and second flows **1051** of aqueous calcined gypsum slurry are discharged from the slurry distributor **1020** upon the first moving web **1039**. The face skim coat/hard edge stream **1049** can be deposited from the mixer **1012** at a point upstream, relative to the direction of movement of the first moving web **1039** in the machine direction **1092**, of where the first and second flows **1047**, **1048** of aqueous calcined gypsum slurry are discharged from the slurry distributor **1020** upon the first moving web **1039**. The combined first and second flows **1047**, **1048** of aqueous calcined gypsum slurry can be discharged from the slurry distributor with a reduced momentum per unit width along the cross-machine direction relative to a conventional boot design to help prevent "washout" of the face skim coat/hard edge stream **1049** deposited on the first moving web **1039** (i.e., the situation where a portion of the deposited skim coat layer is displaced from its position upon the moving web **339** in response to the impact of the slurry being deposited upon it).

The first and second flows **1047**, **1048** of aqueous calcined gypsum slurry respectively passed through the first and second feed inlets **1024**, **1025** of the slurry distributor **1020** can be selectively controlled with at least one flow-modifying element **1023**. For example, in some embodiments, the first and second flows **1047**, **1048** of aqueous calcined gypsum slurry are selectively controlled such that the average velocity of the first flow **1047** of aqueous calcined gypsum slurry passing through the first feed inlet **1024** and the average velocity of the second flow **1048** of aqueous calcined gypsum slurry passing through the second feed inlet **1025** are substantially the same.

In embodiments, the first flow **1047** of aqueous calcined gypsum slurry is passed at an average first feed velocity through the first feed inlet **1024** of the slurry distributor **1020**. The second flow **1048** of aqueous calcined gypsum slurry is passed at an average second feed velocity through the second feed inlet **1025** of the slurry distributor **1020**. The second feed inlet **1025** is in spaced relationship to the first feed inlet **1024**. The first and second flows **1051** of aqueous calcined gypsum slurry are combined in the slurry distributor **1020**. The combined first and second flows **1051** of aqueous calcined gypsum slurry are discharged at an average discharge velocity from a distribution outlet **1030** of the slurry distributor **1020** upon the web **1039** of cover sheet material moving along a machine direction **1092**. The average discharge velocity is less than the average first feed velocity and the average second feed velocity.

In some embodiments, the average discharge velocity is less than about 90% of the average first feed velocity and the average second feed velocity. In some embodiments, the average discharge velocity is less than about 80% of the average first feed velocity and the average second feed velocity.

The combined first and second flows **1051** of aqueous calcined gypsum slurry are discharged from the slurry distributor **1020** through the distribution outlet **1030**. The opening of the distribution outlet **1030** has a width extending along the transverse axis **60** and sized such that the ratio of the width of the first moving web **1039** of cover sheet material to the width of the opening of the distribution outlet **1030** is within a range including and between about 1:1 and about 6:1. In some embodiments, the ratio of the average velocity of the combined first and second flows **1051** of aqueous calcined gypsum slurry discharging from the slurry distributor **1020** to the velocity of the moving web **1039** of cover sheet material moving along the machine direction **1092** can be about 2:1 or less in some embodiments, and from about 1:1 to about 2:1 in other embodiments.

The combined first and second flows **1051** of aqueous calcined gypsum slurry discharging from the slurry distributor **1020** form a spread pattern upon the moving web **1039**. At least one of the size and shape of the distribution outlet **1030** can be adjusted, which in turn can change the spread pattern.

Thus, slurry is fed into both feed inlets **1024**, **1025** of the feed conduit **1022** and then exits through the distribution outlet **1030** with an adjustable gap. A converging portion **1082** can provide a slight increase in the slurry velocity so as to reduce unwanted exit effects and thereby further improve flow stability at the free surface. Side-to-side flow variation and/or any local variations can be reduced by performing cross-machine (CD) profiling control at the discharge outlet **1030** using the profiling system. This distribution system can help prevent air-liquid slurry separation in the slurry resulting in a more uniform and consistent material delivered to the forming table **1038**.

A back skim coat stream **1053** (a layer of denser aqueous calcined gypsum slurry relative to at least one of the first and second flows **1047**, **1048** of aqueous calcined gypsum slurry) can be applied to the second moving web **1043**. The back skim coat stream **1053** can be deposited from the mixer **1012** at a point upstream, relative to the direction of movement of the second moving web **1043**, of the back skim coat roller **1037**.

In other embodiments, the average velocity of the first and second flows **1047**, **1048** of aqueous calcined gypsum slurry are varied. In some embodiments, the slurry velocities at the feed inlets **1024**, **1025** of the feed conduit **1022** can oscillate periodically between relatively higher and lower average velocities (at one point in time one inlet has a higher velocity than the other inlet, and then at a predetermined point in time vice versa) to help reduce the chance of buildup within the geometry itself.

In embodiments, the first flow **1047** of aqueous calcined gypsum slurry passing through the first feed inlet **1024** has a shear rate that is lower than the shear rate of the combined first and second flows **1051** discharging from the distribution outlet **1030**, and the second flow **1048** of aqueous calcined gypsum slurry passing through the second feed inlet **1025** has a shear rate that is lower than the shear rate of the combined first and second flows **1051** discharging from the distribution outlet **1030**. In embodiments, the shear rate of the combined first and second flows **1051** discharging from the distribution outlet **1030** can be greater than about 150% of the shear rate of the first flow **1047** of aqueous calcined gypsum slurry passing through the first feed inlet **1024** and/or the second flow **1048** of aqueous calcined gypsum slurry passing through the second feed inlet **1025**, greater than about 175% in still other embodiments, and about double or greater in yet other embodiments. It should be understood that the viscosity of the first and second flows **1047**, **1048** of aqueous calcined gypsum slurry and the combined first and second flows **1051** can be inversely related to the shear rate present at a given location such that as the shear rate goes up, the viscosity decreases.

In embodiments, the first flow **1047** of aqueous calcined gypsum slurry passing through the first feed inlet **1024** has a shear stress that is lower than the shear stress of the combined first and second flows **1051** discharging from the distribution outlet **1030**, and the second flow **1048** of aqueous calcined gypsum slurry passing through the second feed inlet **1025** has a shear stress that is lower than the shear stress of the combined first and second flows **1051** discharging from the distribution outlet **1030**. In embodiments, the shear stress of the combined first and second flows **1051** discharging from the distribution outlet **1030** can be greater than about 110% of the shear rate of the first flow **1047** of aqueous calcined gypsum slurry passing through the first feed inlet **1024** and/or the second flow **1048** of aqueous calcined gypsum slurry passing through the second feed inlet **1025**.

In embodiments, the first flow **1047** of aqueous calcined gypsum slurry passing through the first feed inlet **1024** has a Reynolds number that is higher than the Reynolds number of the combined first and second flows **1051** discharging from the distribution outlet **1030**, and the second flow **1048** of aqueous calcined gypsum slurry passing through the second feed inlet **1025** has a Reynolds number that is higher than the Reynolds number of the combined first and second flows **1051** discharging from the distribution outlet **1030**. In embodiments, the Reynolds number of the combined first and second flows **1051** discharging from the distribution outlet **1030** can be less than about 90% of the Reynolds number of the first flow **1047** of aqueous calcined gypsum slurry passing through the first feed inlet **1024** and/or the second flow **1048** of aqueous calcined gypsum slurry passing through the second feed inlet **1025**, less than about 80% in still other embodiments, and less than about 70% in still other embodiments.

Referring to FIG. **30**, an embodiment of a Y-shaped flow splitter **1100** suitable for use in a gypsum slurry mixing and dispensing assembly constructed in accordance with principles of the present disclosure is shown. The flow splitter **1100** can be placed in fluid communication with a gypsum slurry mixer and a slurry distributor such that the flow splitter **1100** receives a single flow of aqueous calcined gypsum slurry from the mixer and discharges two separate flows of aqueous calcined gypsum slurry therefrom to the first and second feed inlets of the slurry distributor. One or more flow-modifying elements can be disposed between the mixer and the flow splitter **1100** and/or between one or both of the delivery branches leading between the splitter **1100** and the associated slurry distributor.

The flow splitter **1100** has a substantially circular inlet **1102** disposed in a main branch **1103** adapted to receive a single flow of slurry and a pair of substantially circular outlets **1104**, **1106** disposed respectively in first and second outlet branches **1105**, **1107** that allow two flows of slurry to discharge from the splitter **1100**. The cross-sectional areas of the openings of the inlet **1102** and the outlets **1104**, **1106** can vary depending on the desired flow velocity. In embodiments where the cross-sectional areas of the openings of outlet **1104**, **1106** are each substantially equal to cross-sectional area of the opening of the inlet **1102**, the flow velocity of the slurry discharging from each outlet **1104**, **1106** can be reduced to about 50% of the velocity of the single flow of slurry entering the inlet **1102** where the volumetric flow rate through the inlet **1102** and both outlets **1104**, **1106** is substantially the same.

In some embodiments, the diameter of the outlets **1104**, **1106** can be made smaller than the diameter of the inlet **1102** in order to maintain a relatively high flow velocity throughout the splitter **1100**. In embodiments where the cross-sectional areas of the openings of the outlets **1104**, **1106** are each smaller than the cross-sectional area of the opening of the inlet **1102**, the flow velocity can be maintained in the outlets **1104**, **1106** or at least reduced to a lesser extent than if the outlets **1104**, **1106** and the inlet **1102** all have substantially equal cross-sectional areas. For example, in some embodiments, the flow splitter **1100** has the inlet **1102** has an inner diameter (ID_1) of about 3 inches, and each outlet **1104**, **1106** has an ID_2 of about 2.5 inches (though other inlet and outlet diameters can be used in other embodiments). In an embodiment with these dimensions at a line speed of 350 fpm, the smaller diameter of the outlets **1104**, **1106** causes the flow velocity in each outlet to be reduced by about 28% of the flow velocity of the single flow of slurry at the inlet **1102**.

The flow splitter **1100** can includes a central contoured portion **1114** and a junction **1120** between the first and second outlet branches **1105**, **1107**. The central contoured portion **1114** creates a restriction **1108** in the central interior region of the flow splitter **1100** upstream of the junction **1120** that helps promote flow to the outer edges **1110**, **1112** of the splitter to reduce the occurrence of slurry buildup at the junction **1120**. The shape of the central contoured portion **1114** results in guide channels **1111**, **1113** adjacent the outer edges **1110**, **1112** of the flow splitter **1100**. The restriction **1108** in the central contoured portion **1114** has a smaller height H_2 than the height H_3 of the guide channels **1111**, **1113**. The guide channels **1111**, **1113** have a cross-sectional area that is larger than the cross-sectional area of the central restriction **1108**. As a result, the flowing slurry encounters less flow resistance through the guide channels **1111**, **1113** than through the central restriction **1108**, and flow is directed toward the outer edges of the splitter junction **1120**.

The junction **1120** establishes the openings to the first and second outlet branches **1105**, **1107**. The junction **1120** is made up of a planar wall surface **1123** that is substantially perpendicular to an inlet flow direction **1125**.

Referring to FIG. **32**, in some embodiments, an automatic device **1150** for squeezing the splitter **1100** at adjustable and regular time intervals can be provided to prevent solids building up inside the splitter **1100**. In some embodiments, the squeezing apparatus **1150** can include a pair of plates **1152**, **1154** disposed on opposing sides **1142**, **1143** of the central contoured portion **1114**. The plates **1152**, **1154** are movable relative to each other by a suitable actuator **1160**. The actuator **1160** can be operated either automatically or selectively to move the plates **1152**, **1154** together relative to each other to apply a compressive force upon the splitter **1100** at the central contoured portion **1114** and the junction **1120**.

When the squeezing apparatus **1150** squeezes the flow splitter, the squeezing action applies compressive force to the flow splitter **1100**, which flexes inwardly in response. This compressive force can help prevent buildup of solids inside the splitter **1100** which may disrupt the substantially equally split flow to the slurry distribution through the outlets **1104**, **1106**. In some embodiments, the squeezing apparatus **1150** is designed to automatically pulse through the use of a programmable controller operably arranged with the actuators. The time duration of the application of the compressive force by the squeezing apparatus **1150** and/or the interval between pulses can be adjusted. Furthermore, the stroke length that the plates **1152**, **1154** travel with respect to each other in a compressive direction can be adjusted.

Embodiments of a slurry distributor, a gypsum slurry mixing and dispensing assembly, and methods of using the same are provided herein which can provide many enhanced process features helpful in manufacturing gypsum wallboard in a commercial setting. A slurry distributor constructed in accordance with principles of the present disclosure can facilitate the spreading of aqueous calcined gypsum slurry upon a moving web of cover sheet material as it advances past a mixer at the wet end of the manufacturing line toward a forming station.

A gypsum slurry mixing and dispensing assembly constructed in accordance with principles of the present disclosure can split a flow of aqueous calcined gypsum slurry from a mixer into two separate flows of aqueous calcined gypsum slurry which can be recombined downstream in a slurry distributor constructed in accordance with principles of the present disclosure to provide a desired spreading pattern. The design of the dual inlet configuration and the distribution outlet can allow for wider spreading of more viscous slurry in the cross-machine direction over the moving web of cover sheet material. The slurry distributor can be adapted such that the two separate flows of aqueous calcined gypsum slurry enter a slurry distributor along feed inlet directions which include a cross-machine direction component, are re-directed inside the slurry distributor such that the two flows of slurry are moving in substantially a machine direction, and are recombined in the distributor in a way to enhance the cross-direction uniformity of the combined flows of aqueous calcined gypsum slurry being discharged from the distribution outlet of the slurry distributor to help reduce mass flow variation over time along the transverse axis or cross machine direction. Introducing the first and second flows of aqueous calcined gypsum slurry in first and second feed directions that include a cross-machine directional component can help the re-combined flows of slurry discharge from the slurry distributor with a reduced momentum and/or energy.

The interior flow cavity of the slurry distributor can be configured such that each of the two flows of slurry move through the slurry distributor in a streamline flow. The interior flow cavity of the slurry distributor can be configured such that each of the two flows of slurry move through the slurry distributor with minimal or substantially no air-liquid slurry phase separation. The interior flow cavity of the slurry distributor can be configured such that each of the two flows of slurry move through the slurry distributor substantially without undergoing a vortex flow path.

A gypsum slurry mixing and dispensing assembly constructed in accordance with principles of the present disclosure can include flow geometry upstream of the distribution outlet of the slurry distributor to reduce the slurry velocity in one or multiple steps. For example, a flow splitter can be provided between the mixer and the slurry distributor to reduce the slurry velocity entering the slurry distributor. As another example, the flow geometry in the gypsum slurry mixing and dispensing assembly can include areas of expansion upstream and within the slurry distributor to slow down the slurry so it is manageable when it is discharged from the distribution outlet of the slurry distributor.

The geometry of the distribution outlet can also help control the discharge velocity and momentum of the slurry as it is being discharged from the slurry distributor upon the moving web of cover sheet material. The flow geometry of the slurry distributor can be adapted such that the slurry discharging from the distribution outlet is maintained in substantially a two-dimensional flow pattern with a relatively small height in comparison to the wider outlet in the cross-machine direction to help improve stability and uniformity.

The relatively wide discharge outlet yields a momentum per unit width of the slurry being discharged from the distribution outlet that is lower than the momentum per unit width of a slurry discharged from a conventional boot under similar operating conditions. The reduced momentum per unit width can help prevent washout of a skim coat of a dense layer applied to the web of cover sheet material upstream from the location where the slurry is discharged from the slurry distributor upon the web.

In the situation where a conventional boot outlet is 6 inches wide and 2 inches thick is used, the average velocity of the outlet for a high volume product can be about 761 ft/min. In embodiments where the slurry distributor constructed in accordance with principles of the present disclosure includes a distribution outlet having an opening that is 24 inches wide and 0.75 inches thick, the average velocity can be about 550 ft/min. The mass flow rate is the same for both devices at 3,437 lb/min. The momentum of the slurry (mass flow rate*average velocity) for both cases would be ~2,618,000 and 1,891,000 lb·ft/min^2 for the conventional boot and the slurry distributor, respectively. Dividing the respective calculated momentum by the widths of the conventional boot outlet and the slurry distributor outlet, the momentum per unit width of the slurry discharging from the convention boot is 402,736 (lb·ft/min^2)/(inch across boot width), and the momentum per unit width of the slurry discharging from the slurry distributor constructed in accordance with principles of the present disclosure is 78,776 (lb·ft/min^2)/(inch across slurry distributor width). In this case, the slurry discharging from the slurry distributor has about 20% of the momentum per unit width compared to the conventional boot.

A slurry distributor constructed in accordance with principles of the present disclosure can achieve a desired spreading pattern while using an aqueous calcined gypsum slurry over a broad range of water-stucco ratios, including a relatively low WSR or a more conventional WSR, such as, a water-to-calcined gypsum ratio from about 0.4 to about 1.2, for example, below 0.75 in some embodiments, and between about 0.4 and about 0.8 in other embodiments. Embodiments of a slurry distributor constructed in accordance with principles of the present disclosure can include internal flow geometry adapted to generate controlled shear effects upon the first and second flows of aqueous calcined gypsum slurry as the first and second flows advance from the first and second feed inlets through the slurry distributor toward the distribution outlet. The application of controlled shear in the slurry distributor can selectively reduce the viscosity of the slurry as a result of being subjected to such shear. Under the effects of controlled shear in the slurry distributor, slurry having a lower water-stucco ratio can be distributed from the slurry distributor with a spread pattern in the cross-machine direction comparable to slurries having a conventional WSR.

The interior flow geometry of the slurry distributor can be adapted to further accommodate slurries of various water-stucco ratios to provide increase flow adjacent the boundary wall regions of the interior geometry of the slurry distributor. By including flow geometry features in the slurry distributor adapted to increase the degree of flow around the boundary wall layers, the tendency of slurry to re-circulate in the slurry distributor and/or stop flowing and set therein is reduced. Accordingly, the build up of set slurry in the slurry distributor can be reduced as a result.

A slurry distributor constructed in accordance with principles of the present disclosure can include a profile system mounted adjacent the distribution outlet to alter a cross machine velocity component of the combined flows of slurry discharging from the distribution outlet to selectively control the spread angle and spread width of the slurry in the cross machine direction on the substrate moving down the manufacturing line toward the forming station. The profile system can help the slurry discharged from the distribution outlet achieve a desired spread pattern while being less sensitive to slurry viscosity and WSR. The profile system can be used to change the flow dynamics of the slurry discharging from the distribution outlet of the slurry distributor to guide slurry flow such that the slurry has more uniform velocity in the cross-machine direction. Using the profile system can also help a gypsum slurry mixing and dispensing assembly constructed in accordance with principles of the present disclosure be used in a gypsum wallboard manufacturing setting to produce wallboard of different types and volumes.

EXAMPLES

Referring to FIG. **33**, in these Examples the geometry and flow characteristics of a slurry distributor constructed in accordance with principles of the present disclosure were evaluated. A top plan view of a half portion **1205** of a slurry distributor is shown in FIG. **33**. The half portion **1205** of the slurry distributor includes a half portion **1207** of a feed conduit **320** and a half portion **1209** of a distribution conduit **328**. The half portion **1207** of the feed conduit **322** includes a second feed inlet **325** defining a second opening **335**, a second entry segment **337**, and a half portion **1211** of a bifurcated connector segment **339**. The half portion **1209** of the distribution conduit **328** includes a half portion **1214** of an entry portion **352** of the distribution conduit **328** and a half portion **1217** of a distribution outlet **330**.

It should be understood that another half portion of a slurry distributor, which is a mirror image of the half portion **1205** of FIG. **33**, can be integrally joined and aligned with the half portion **1205** of FIG. **33** at a transverse central midpoint **387** of the distribution outlet **330** to form a slurry distributor which is substantially similar to the slurry distributor **420** of FIG. **15**. Accordingly, the geometry and flow characteristics described below are equally applicable to the mirror image half portion of the slurry distributor as well.

Example 1

In this Example and referring to FIG. **33**, the particular geometry of the half portion **1205** of the slurry distributor was evaluated at sixteen different locations L_{1-16} between a first location L_1 at the second feed inlet **325** and a sixteenth location L_{16} at a half portion **1207** of the distribution outlet **330**. Each location L_{1-16} represents a cross-sectional slice of the half portion **1205** of the slurry distributor as indicated by the corresponding line. A flow line **1212** along the geometric center of each cross-sectional slice was used to determine the distance between adjacent locations L_{1-16}. The eleventh location L_{11} corresponds to the half portion **1214** of the entry portion **352** of the distribution conduit **328** which corresponds to an opening **342** of a second feed outlet **345** of the half portion **1207** of the feed conduit **320**. Accordingly, the first through the tenth locations L_{1-10} are taken in the half portion **1207** of the feed conduit **320**, and the eleventh through the sixteenth locations are taken in the half portion **1209** of the distribution conduit **328**.

For each location L_{1-16}, the following geometric values of were determined: the distance along the flow line **1212** between the second feed inlet **325** and the particular location L_{1-16}; the cross-sectional area of the opening at the location L_{1-16}; the perimeter of the location L_{1-16}; and the hydraulic diameter of the location L_{1-16}. The hydraulic diameter was calculated using the following formula:

$$D_{hyd}=4\times A/P \quad \text{(Eq. 1)}$$

where D_{hyd} is the hydraulic diameter,

A is the area of the particular location L_{1-16}, and

P is the perimeter of the particular location L_{1-16}.

Using the inlet conditions, the dimensionless values for each location L_{1-16} can be determined to describe the interior flow geometry, as shown in Table 1. Curve-fit equations were used to describe the dimensionless geometry of the half portion **1205** of the slurry distributor in FIG. **34**, which shows the dimensionless distance from inlet versus the dimensionless area and the hydraulic diameter.

The analysis of the dimensionless values for each location L_{1-16} shows that the cross sectional flow area increases from the first location L_1 at the second feed inlet **325** to the eleventh location L_{11} at the half portion **1214** of the entry portion **352** (also the opening **342** of the second feed outlet **345**). In the exemplary embodiment, the cross-sectional flow area at the half portion **1214** of the entry portion **352** is about ⅓ larger than the cross-sectional flow area at the second feed inlet **325**. Between the first location L_1 and the eleventh location L_{11}, the cross-sectional flow area of the second entry segment **337** and the second shaped duct **339** varies from location to location L_{1-11}. In this region, at least two adjacent locations L_6, L_7 are configured such that the location L_7 located further from the second feed inlet **325** has a cross sectional flow area that is smaller than the adjacent location L_6 that is closer to the second feed inlet **325**.

Between the first location L_1 and the eleventh location L_{11}, in the half portion **1207** of the feed conduit **322** there is an area of expansion (e.g., L_{4-6}) having a cross-sectional flow area that is greater than a cross-sectional flow area of an adjacent area (e.g., L_3) upstream from the area of expansion in a direction from the second inlet **335** toward the half portion **1217** of the distribution outlet **330**. The second entry segment **337** and the second shaped duct **341** have a cross section that varies along the direction of flow **1212** to help distribute the second flow of slurry moving therethrough.

The cross sectional area decreases from the eleventh location L_{11} at the half portion **1214** of the entry portion **352** of the distribution conduit **328** to the sixteenth location L_{16} at the half portion **1217** of the distribution outlet **330** of the distribution conduit **328**. In the exemplary embodiment, the cross-sectional flow area of the half portion **1214** of an entry portion **352** is about 95% of that of the half portion **1217** of the distribution outlet **330**.

The cross-sectional flow area at the first location L_1 at the second feed inlet **325** is smaller than the cross-sectional flow area at the sixteenth location L_{16} at the half portion **1217** of the distribution outlet **330** of the distribution conduit **328**. In the exemplary embodiment, the cross-sectional flow area at the half portion **1217** of the distribution outlet **330** of the distribution conduit **328** is about ¼ larger than the cross-sectional flow area at the second feed inlet **325**.

The hydraulic diameter decreases from the first location L_1 at the second feed inlet **325** to the eleventh location L_{11} at the half portion **1214** of the entry portion **352** of the distribution conduit **328**. In the exemplary embodiment, the hydraulic diameter at the half portion **1214** of the entry portion **352** of the distribution conduit **328** is about ½ the hydraulic diameter at the second feed inlet **325**.

The hydraulic diameter decreases from the eleventh location L_{11} at the half portion **1214** of an entry portion **352** of the distribution conduit **328** to the sixteenth location L_{16} at the half portion **1217** of the distribution outlet **330** of the distribution conduit **328**. In the exemplary embodiment, the hydraulic diameter of the half portion **1217** of the distribution outlet **330** of the distribution conduit **328** is about 95% of that of the half portion **1214** of the entry portion **352** of the distribution conduit **328**.

The hydraulic diameter at the first location L_1 at the second inlet **325** is larger than the hydraulic diameter at the sixteenth location L_{16} at the half portion **1217** of the distribution outlet **330** of the distribution conduit **328**. In the exemplary embodiment, the hydraulic diameter at the half portion **1217** of the distribution outlet **330** of the distribution conduit **328** is less than about half of that of the second feed inlet **325**.

TABLE I

GEOMETRY

	Dimensionless			
Location	Distance From Inlet	Area	Perimeter	Hydraulic Dia.
L1	0.00	1.00	1.00	1.00
L2	0.07	1.00	1.00	1.00
L3	0.14	0.91	0.98	0.93
L4	0.20	1.01	1.07	0.94
L5	0.27	1.18	1.24	0.95
L6	0.34	1.25	1.45	0.87
L7	0.41	1.16	1.68	0.69
L8	0.47	1.13	1.93	0.59
L9	0.54	1.23	2.20	0.56
L10	0.61	1.35	2.47	0.55
L11	0.68	1.33	2.73	0.49
L12	0.75	1.28	2.70	0.47
L13	0.81	1.27	2.68	0.48
L14	0.88	1.26	2.67	0.47
L15	0.95	1.26	2.67	0.47
L16	1.00	1.26	2.67	0.47

Example 2

In this Example, the half portion **1205** of the slurry distributor of FIG. **33** was used to model the flow of gypsum slurry therethrough under different flow conditions. For all flow conditions, the density (ρ) of the aqueous gypsum slurry was set at 1,000 kg/m³. Aqueous gypsum slurry is a shear-thinning material such that as shear is applied to it, its viscosity can decrease. The viscosity (μ) Pa·s of the gypsum slurry was calculated using the Power Law Fluid Model which has the following equation:

$$\mu=K\dot{\gamma}^{n-1} \quad \text{(Eq. 2)}$$

where,

K is a constant,

$\dot{\gamma}$ is the shear rate, and

n is a constant equal to 0.133 in this case.

In a first flow condition, the gypsum slurry has a viscosity K factor of 50 in the Power Law model and enters the second feed inlet **325** at 2.5 m/s. A computational fluid dynamics technique with a finite volume method was used to determine flow characteristics in the distributor. At each location L_{1-16}, the following flow characteristics were determined: area-weighted average velocity (U), area-weighted average shear rate ($\dot{\gamma}$), viscosity calculated using the Power Law Model (Eq. 2), shear stress, and Reynolds Number (Re).

The shear stress was calculated using the following equation:

$$\text{Shear stress} = \mu \times \dot{\gamma} \quad \text{(Eq. 3)}$$

where

μ is the viscosity calculated using the Power Law Model (Eq. 2), and

$\dot{\gamma}$ is the shear rate.

The Reynolds Number was calculated using the following equation:

$$Re == \rho \times U \times D_{hyd}/\mu \quad \text{(Eq. 4)}$$

where

ρ is the density of the gypsum slurry,

U is the area-weighted average velocity,

D_{hyd} is the hydraulic diameter, and

μ is the viscosity calculated using the Power Law Model (Eq. 2).

In a second flow condition case, the feed velocity of the gypsum slurry into the second feed inlet **325** was increased to 3.55 m/s. All other conditions were the same as in the first flow condition of this Example. The dimensional values for the mentioned flow characteristics at each location L_{1-16} for both the first flow condition where the inlet velocity is 2.5 m/s and the second flow condition where the inlet velocity is 3.55 m/s were modeled. Using the inlet conditions, dimensionless values of the flow characteristics for each location L_{1-16} were determined, as shown in Table II.

For both flow conditions where K was set equal to 50, the average velocity was reduced from the first location L_1 at the second feed inlet **325** to the sixteenth location L_{16} at the half portion **1217** of the distribution outlet **330** of the distribution conduit **328**. In the illustrated embodiment, the average velocity was reduced by about ⅕.

For both flow conditions, the shear rate increased from the first location L_1 at the second feed inlet **325** to the sixteenth location L_{16} at the half portion **1217** of the distribution outlet **330** of the distribution conduit **328**. In the illustrated embodiment, the shear rate approximately doubled from the first location L_1 at the second feed inlet **325** to the sixteenth location L_{16} at the half portion **1217** of the distribution outlet **330** of the distribution conduit **328**, as shown in FIG. **36**.

For both flow conditions, the calculated viscosity was reduced from the first location L_1 at the second feed inlet **325** to the sixteenth location L_{16} at the half portion **1217** of the distribution outlet **330** of the distribution conduit **328**. In the illustrated embodiment, the calculated viscosity was reduced from the first location L_1 at the second feed inlet **325** to the sixteenth location L_{16} at the half portion **1217** of the distribution outlet **330** of the distribution conduit **328** by about half, as illustrated in FIG. **37**.

For both flow conditions in FIG. **38**, the shear stress increased from the first location L_1 at the second feed inlet **325** to the sixteenth location L_{16} at the half portion **1217** of the distribution outlet **330** of the distribution conduit **328**. In the illustrated embodiment, the shear stress increased by about 10% from the first location L_1 at the second feed inlet **325** to the sixteenth location L_{16} at the half portion **1217** of the distribution outlet **330** of the distribution conduit **328**.

For both flow conditions, the Reynolds number in FIG. **39** was reduced from the first location L_1 at the second feed inlet **325** to the sixteenth location L_{16} at the half portion **1217** of the distribution outlet **330** of the distribution conduit **328**. In the illustrated embodiment, the Reynolds number was reduced from the first location L_1 at the second feed inlet **325** to the sixteenth location L_{16} at the half portion **1217** of the distribution outlet **330** of the distribution conduit **328** by about ⅓. For both flow conditions, the Reynolds number at the sixteenth location L_{16} at the half portion **1217** of the distribution outlet **330** of the distribution conduit **328** is in the laminar region.

TABLE II

DIMENSIONLESS FLOW CHARACTERISTICS (K = 50)

	Inlet Velocity = 2.50 m/s					Inlet Velocity = 3.55 m/s				
Location	Velocity	Shear Rate	Calc Visc.	Shear Stress	Re	Velocity	Shear Rate	Calc Visc.	Shear Stress	Re
L1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
L2	1.00	1.18	0.87	1.02	1.15	1.00	1.20	0.85	1.03	1.17
L3	1.10	1.36	0.77	1.04	1.33	1.10	1.40	0.75	1.05	1.36
L4	1.00	1.30	0.80	1.04	1.18	0.99	1.32	0.79	1.04	1.19
L5	0.86	1.19	0.86	1.02	0.96	0.86	1.22	0.84	1.03	0.98
L6	0.83	1.23	0.83	1.03	0.86	0.83	1.28	0.81	1.03	0.89
L7	0.90	1.65	0.65	1.07	0.96	0.90	1.73	0.62	1.08	0.99
L8	0.90	1.73	0.62	1.08	0.85	0.90	1.80	0.60	1.08	0.88
L9	0.82	1.67	0.64	1.07	0.72	0.82	1.74	0.62	1.08	0.74
L10	0.77	1.63	0.65	1.07	0.64	0.77	1.73	0.62	1.08	0.68
L11	0.76	1.83	0.59	1.08	0.62	0.76	1.93	0.57	1.09	0.65
L12	0.78	1.84	0.59	1.08	0.63	0.78	1.92	0.57	1.09	0.65
L13	0.78	1.88	0.58	1.09	0.64	0.78	1.93	0.57	1.09	0.65
L14	0.78	1.88	0.58	1.09	0.64	0.78	1.95	0.56	1.09	0.66
L15	0.78	1.85	0.59	1.09	0.63	0.78	1.92	0.57	1.09	0.65
L16	0.79	1.89	0.58	1.09	0.65	0.79	1.98	0.55	1.09	0.67

Example 3

In this Example, the half portion **1205** of the slurry distributor of FIG. **33** was used to model the flow of gypsum slurry therethrough under flow conditions similar to those in Example 2 except that the value for the coefficient K in the Power Law Model (Eq. 2) was set at 100. The flow conditions were similar to those in Example 2 in other respects.

Again, the flow characteristics were evaluated both for a feed velocity of the gypsum slurry into the second feed inlet **325** of 2.50 m/s and of 3.55 m/s. At each location L_{1-16}, the following flow characteristics were determined: area-weighted average velocity (U), area-weighted average shear rate ($\dot{\gamma}$), viscosity calculated using the Power Law Model (Eq. 2), shear stress (Eq. 3), and Reynolds Number (Re) (Eq. 4). Using the inlet conditions, dimensionless values of the flow characteristics for each location L_{1-16} were determined, as shown in Table III.

For both flow conditions where K was set equal to 100, the average velocity was reduced from the first location L_1 at the second feed inlet **325** to the sixteenth location L_{16} at the half portion **1217** of the distribution outlet **330** of the distribution conduit **328**. In the illustrated embodiment, the average velocity was reduced by about ⅕. The results for average velocity, on a dimensionless basis, were substantially the same as those in Example 2 and FIG. **35**.

For both flow conditions, the shear rate increased from the first location L_1 at the second feed inlet **325** to the sixteenth location L_{16} at the half portion **1217** of the distribution outlet **330** of the distribution conduit **328**. In the illustrated embodiment, the shear rate approximately doubled from the first location L_1 at the second feed inlet **325** to the sixteenth location L_{16} at the half portion **1217** of the distribution outlet **330** of the distribution conduit **328**. The results for shear rate, on a dimensionless basis, were substantially the same as those in Example 2 and FIG. **36**.

For both flow conditions, the calculated viscosity was reduced from the first location L_1 at the second feed inlet **325** to the sixteenth location L_{16} at the half portion **1217** of the distribution outlet **330** of the distribution conduit **328**. In the illustrated embodiment, the calculated viscosity was reduced from the first location L_1 at the second feed inlet **325** to the sixteenth location L_{16} at the half portion **1217** of the distribution outlet **330** of the distribution conduit **328** by about half. The results for the calculated viscosity, on a dimensionless basis, were substantially the same as those in Example 2 and FIG. **37**.

For both flow conditions, the shear stress increased from the first location L_1 at the second feed inlet **325** to the sixteenth location L_{16} at the half portion **1217** of the distribution outlet **330** of the distribution conduit **328**. In the illustrated embodiment, the shear stress increased by about 10% from the first location L_1 at the second feed inlet **325** to the sixteenth location L_{16} at the half portion **1217** of the distribution outlet **330** of the distribution conduit **328**. The results for the shear stress, on a dimensionless basis, were substantially the same as those in Example 2 and FIG. **38**.

For both flow conditions, the Reynolds number was reduced from the first location L_1 at the second feed inlet **325** to the sixteenth location L_{16} at the half portion **1217** of the distribution outlet **330** of the distribution conduit **328**. In the illustrated embodiment, the Reynolds number was reduced from the first location L_1 at the second feed inlet **325** to the sixteenth location L_{16} at the half portion **1217** of the distribution outlet **330** of the distribution conduit **328** by about ⅓. For both flow conditions, the Reynolds number at the sixteenth location L_{16} at the half portion **1217** of the distribution outlet **330** of the distribution conduit **328** is in the laminar region. The results for the Reynolds number, on a dimensionless basis, were substantially the same as those in Example 2 and FIG. **39**.

FIGS. **34-38** are graphs of the flow characteristics computed for the different flow conditions of Examples 2 and 3. Curve-fit equations were used to describe the change in the flow characteristics over the distance between the feed inlet to the half portion of the distribution outlet. Accordingly, the Examples show that the flow characteristics are consistent over variations in inlet velocity and/or viscosity.

TABLE III

DIMENSIONLESS FLOW CHARACTERISTICS (K = 100)

	Inlet Velocity = 2.50 m/s					Inlet Velocity = 3.55 m/s				
Location	Velocity	Shear Rate	Calc Visc.	Shear Stress	Re	Velocity	Shear Rate	Calc Visc.	Shear Stress	Re
L1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
L2	1.00	1.16	0.88	1.02	1.13	1.00	1.21	0.85	1.03	1.18
L3	1.10	1.35	0.77	1.04	1.32	1.10	1.39	0.75	1.04	1.35
L4	1.00	1.28	0.80	1.03	1.17	1.00	1.35	0.77	1.04	1.22
L5	0.87	1.15	0.88	1.02	0.94	0.86	1.23	0.84	1.03	0.99
L6	0.83	1.18	0.87	1.02	0.83	0.83	1.27	0.81	1.03	0.88
L7	0.90	1.60	0.66	1.06	0.93	0.90	1.70	0.63	1.07	0.98
L8	0.90	1.70	0.63	1.07	0.84	0.90	1.77	0.61	1.08	0.87
L9	0.82	1.61	0.66	1.07	0.69	0.82	1.71	0.63	1.07	0.73
L10	0.77	1.57	0.68	1.06	0.62	0.77	1.67	0.64	1.07	0.66
L11	0.76	1.76	0.61	1.08	0.60	0.76	1.88	0.58	1.09	0.64
L12	0.78	1.79	0.60	1.08	0.61	0.78	1.90	0.57	1.09	0.64
L13	0.78	1.81	0.60	1.08	0.62	0.78	1.93	0.57	1.09	0.65
L14	0.78	1.84	0.59	1.08	0.63	0.78	1.94	0.56	1.09	0.66
L15	0.78	1.80	0.60	1.08	0.62	0.78	1.90	0.57	1.09	0.64
L16	0.79	1.87	0.58	1.09	0.64	0.79	1.96	0.56	1.09	0.67

All references, including publications, patent applications, and patents, cited herein are hereby incorporated by reference to the same extent as if each reference were individually and specifically indicated to be incorporated by reference and were set forth in its entirety herein.

The use of the terms "a" and "an" and "the" and similar referents in the context of describing the invention (especially in the context of the following claims) are to be construed to cover both the singular and the plural, unless otherwise indicated herein or clearly contradicted by context. The terms "comprising," "having," "including," and "containing" are to be construed as open-ended terms (i.e., meaning "including, but not limited to,") unless otherwise noted. Recitation of ranges of values herein are merely intended to serve as a shorthand method of referring individually to each separate value falling within the range, unless otherwise indicated herein, and each separate value is incorporated into the specification as if it were individually recited herein. All methods described herein can be performed in any suitable order unless otherwise indicated herein or otherwise clearly contradicted by context. The use of any and all examples, or exemplary language (e.g., "such as") provided herein, is intended merely to better illuminate the invention and does not pose a limitation on the scope of the invention unless otherwise claimed. No language in the specification should be construed as indicating any non-claimed element as essential to the practice of the invention.

Preferred embodiments of this invention are described herein, including the best mode known to the inventors for carrying out the invention. Variations of those preferred embodiments may become apparent to those of ordinary skill in the art upon reading the foregoing description. The inventors expect skilled artisans to employ such variations as appropriate, and the inventors intend for the invention to be practiced otherwise than as specifically described herein. Accordingly, this invention includes all modifications and equivalents of the subject matter recited in the claims appended hereto as permitted by applicable law. Moreover, any combination of the above-described elements in all possible variations thereof is encompassed by the invention unless otherwise indicated herein or otherwise clearly contradicted by context.

What is claimed is:

1. A method of making a slurry distributor comprising:

assembling a plurality of mold segments of a multi-piece mold to define an exterior surface of the multi-piece mold;

dipping the assembled multi-piece mold into a solution of flexible material such that at least a portion of the multi-piece mold is submersed in the solution;

removing the multi-piece mold from the solution such that a layer of solution adheres substantially around the exterior surface of the multi-piece mold;

allowing the solution to cure such that an at least partially-solidified molded slurry distributor is formed around the multi-piece mold, wherein the molded slurry distributor has an interior surface defining an interior flow region, the interior surface of the molded slurry distributor being in contacting relationship with the exterior surface of the multi-piece mold, and the molded slurry distributor defines at least two openings each in fluid communication with the interior flow region;

disassembling the multi-piece mold by removing each mold segment from the interior flow region of the slurry distributor through one of the openings of the molded slurry distributor such that each mold segment travels along a respective removal path from its assembled position in the assembled multi-piece mold out through the respective opening;

wherein each mold segment has a maximum cross-sectional area in a plane substantially transverse to the direction of movement of the mold segment along the removal path out of the respective opening of the molded slurry distributor, the maximum cross-sectional area of each mold segment being up to about 150% of the smallest area of the interior flow region of the molded slurry distributor through which the mold segment traverses when moving along the respective removal path;

wherein the slurry distributor includes a feed conduit having a first feed inlet defining one of the openings and a distribution conduit, the distribution conduit extending generally along a longitudinal axis and including an entry portion and a distribution outlet in fluid communication with the entry portion, the entry portion in fluid communication with the first feed inlet of the feed conduit, the distribution outlet defining one of the openings; and

wherein at least two mold segments are removed from the interior flow region of the slurry distributor by following a removal path through the opening of the first feed inlet and at least one mold segment is removed from the interior flow region of the slurry distributor by following a removal path through the opening of the distribution outlet.

2. The method of making a slurry distributor according to claim **1**, wherein at least two mold segments are assembled together by aligning a respective passage defined in the mold segments and inserting a connecting rod through the aligned passages to interconnect the mold segments.

3. The method of making a slurry distributor according to claim **2**, wherein each passage is aligned with at least one respective opening of the molded slurry distributor to allow for the removal of the associated connecting rod from the passage.

4. The method of making a slurry distributor according to claim **1**, wherein at least three mold segments are assembled together by inserting a connecting rod through aligned passages defined therein.

5. The method of making a slurry distributor according to claim **1**, wherein the maximum cross-sectional area of each mold segment is up to about 125% of the smallest area of the interior flow region of the molded slurry distributor through which the mold piece traverses when moving along the respective removal path.

6. The method of making a slurry distributor according to claim **1**, wherein the maximum cross-sectional area of each mold segment is in a range between greater than the smallest area of the interior flow region of the molded slurry distributor through which the mold piece traverses moving along the respective removal path and about 150% thereof.

7. The method of making a slurry distributor according to claim **1**, wherein at least a portion of the interior surface of the molded slurry distributor is substantially a negative image of at least a portion of the exterior surface of the multi-piece mold.

8. The method of making a slurry distributor according to claim **1**, wherein the first feed inlet is disposed at a feed angle in a range up to about 135° with respect to the longitudinal axis.

9. The method of making a slurry distributor according to claim **1**, wherein the feed conduit of the slurry distributor includes a second feed inlet defining one of the openings, the second feed inlet is disposed at a feed angle in a range up to about 135° with respect to the longitudinal axis.

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